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ABSTRACT

Developed as a guide for use by vocational agricultural teachers in preparing curriculum to meet local community/regional needs, this package provides materials for a course on production agriculture and agribusiness occupations. The purpose of the course is to provide 10th grade students with fundamental concepts and skills necessary to explore agricultural occupations, develop job skills, and refine career choices. Supplementary materials include early planning considerations (required and optional materials to be ordered and their sources). Fourteen units are included in this curriculum: orientation, fencing, soils, animal nutrition, public speaking, record books, parliamentary procedure, advanced ferrous welding, preventive maintenance, cereal and forage crops, horticulture, livestock skills, livestock selection review (option unit) and horses and horsemanship (option unit). The orientation unit contains a calendar for the course. Each unit may include some or all of the following components: instructor's guide (unit goal, source of materials, available resource materials, and teaching suggestions), list of unit objectives, student activities, list of teaching aids, suggestions for interest approach, list of references, terms and definitions, teaching outline, informative material, narrative for transparencies, transparency masters, handouts, instructor's manual for slide sets, assignment sheets, answers to assignment sheets, sample quizzes and/or unit tests, and answer keys. (YLB)

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OREGON AGRICULTURE II CURRICULUM GUIDE

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Introduction Preface

Oregon State University's Department of Agricultural Education directed the development of this curriculum package under a grant from the Oregon Department of Education. The opinions expressed herein; however, do not necessarily reflect the position or policy of the Oregon Department of Education, and its endorsement should not be inferred.

Materials used in this curriculum package were adopted from curriculum materials available in other states. We sincerely appreciate and acknowledge the contributions made by the following institutions to the Oregon curriculum guide:

1. Vocational Instructional Services, Texas A & M University.
2. Vocational Agriculture Services, University of Illinois.
3. Vocational Education Productions, California Polytechnic State University.
4. Oklahoma State Department of Vocational and Technical Education, Stillwater, Oklahoma.
5. Oregon State University Extension Materials, Oregon State University.

Gratitude is also expressed here to the members of the Curriculum Project Advisory Committee who advised on content and format as well as field testing the draft copy of the curriculum guide. Members were:

1.	Dave Hall	Wallowa High School
2.	Dave Yost	Joseph High School
3.	Jerry Booth	Hillsboro High School
4.	Phil Ward	Central High School
5.	Jacque Deeds	Clatsop High School
6.	Preston Winn	Sherman County High School
7.	Mike Pratt	Bonanza High School
8.	Mel Thompson	Amity High School
9.	Ron McGee	Cascade High School
10.	Les Geren	Sandy High School
11.	Mike Williams	Gervais High School
12.	Sue Fisher	Silverton High School
13.	Tom Wright	Madras High School
14.	Gary Sundseth	Crook County High School
15.	Charles Ramos	Rogue River High School
16.	Bryan Starr	Sutherlin High School

Selection	Title
I	Introduction A. Table of Contents B. Use of Curriculum Material C. Disadvantage and Handicapped Student Use of this Material D. Sex-Bias Statement E. Planned Course Statement F. Advanced Planning Suggestions G. Curriculum Validation Statement H. Four Year Unit Outline
II	Orientation
III	Fencing
IV	Soils A. Soils B. Fertilizers C. Judging
V	Animal Nutrition A. Digestion B. Feeds C. Rations
VI	Public Speaking
VII	Record Books
VIII	Parliamentary Procedure
IX	Advanced Ferrous Welding A. Arc B. Oxygen - Acetylene
X	Preventive Maintenance
XI	Cereal and Forage Crops
XII	Horticulture (Adjust timing of Unit if this unit is selected for plant science -- see suggestion contained in unit). A. Asexual Propagation B. Pruning
XIII	Livestock Skills A. Handling Livestock B. Castrating, Docking and Dehorning C. Branding and Vaccinating

Selection	Title
XIV	Livestock Selection Review (Option Unit) A. Live Animal Judging B. Carcass Judging and Grading C. Poultry Judging and Egg Grading
XV	Horses and Horsemanship (Option Unit)

Use of Curriculum Material

This curriculum package was developed to be used as a guide which vocational agriculture teachers could use in preparing curriculum which would meet local community/regional needs. The Vocational Agriculture Instructor should use a local Vocational Agriculture Advisory Committee to evaluate the appropriateness of this material to a given locale and eliminate that part of the material which was not appropriate while supplementing with material the advisory committee and instructor deemed appropriate to bring the curriculum package to completion for a specific program.

Remember that the goal of vocational agriculture is to place people in the agricultural occupations of their choice. The instructor should help students set realistic occupational goals in agriculture then, through advisory committee input, designs curriculum which would allow students to meet those goals.

Accountability of vocational programs has been and will continue to be measured by placement of students in occupations appropriate to the subject matter taught. Am important criteria for success with regard to a placement standard would be student selection. If you need help with identifying appropriate student selection criteria refer to the "Policies and Procedures Handbook for Oregon Vocational Agriculture Programs by John Oades and Jacquelyn Deeds. Pages 4 & 101 could be particularly useful to the establishment of a student selection policy.

VOCATIONAL AGRICULTURE AND THE SPECIAL NEEDS LEARNER

Every person in our schools, whether educator or student, differs from everyone else and, therefore, has different needs. Taken to an extreme, nearly everyone has *special needs,* such as, less than 20/20 vision, insufficient upper-body strength, inability to read at a desired level or speed. Most people can overcome or *compensate* for their *special needs.* Insufficient visual acuity can often be corrected by eyeglasses, inadequate strength through the use of other parts of the body as well as technology, low reading skills can be improved if desired and opportunities to learn are available. However, not all persons can *compensate* for their *special needs* without help. These are the persons this section addresses.

1. *Who are special needs learners?*

In the simplest terms, special needs learners are the students who are failing in your vocational program and will continue to do so unless special help is provided. They are also students in your school who have not yet enrolled in your program but who would probably fail if they did without special assistance. In summary, two points are important: (1) they will fail or continue to fail (2) without special help.*

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* There is actually a third criterion. These students are not succeeding or cannot be expected to succeed due to one of the following reasons:

1. A handicap or disability (the student will have or ought to have an individual education plan or IEP).
2. Academic disadvantagement (the student has not adequately learned to read, write, compute or speak but are not disabled or handicapped).
3. Economic disadvantagement (the student has not learned or does not display appropriate work attitudes for employment in agricultural or agribusiness occupation or to succeed in your program).
4. Limited-English proficiency (the student does not speak, understand or write English well enough for employment in agriculture or agribusiness).

These characterizations are important when designing instructional strategies and for no other reason.

2. *How can you help a special needs learner?*

You can provide a critical facet of a special needs learner's life--*EMPLOYABILITY*. Employability means independence and therefore dignity for the special needs learner. However, helping a special needs learner to acquire occupational competence will require the best teaching possible. Effective teaching will require:

* Knowing the special needs student.
* Knowing this curriculum guide thoroughly.
* Knowing which resources are or should be available to you.
* Being a highly creative problem solver.
* Wanting to work with a special needs learner (without this one, all of the above are immaterial).

3. *Where do you begin?*

"PLANNING." You know that good planning is the foundation of effective instruction. This is doubly true for the instruction of special needs learners. Handicapped or disabled learners will or should have individual education programs (IEP). If a handicapped learner will be mainstreamed into your program, you *must* participate in the development of the IEP. You as the occupational expert are a critical member on the IEP team.

The IEP team should also develop an individual vocational education program (IVEP) for each handicapped learner. The IVEP should describe in detail: (1) the competencies that the student should learn, (2) where the student will learn each competency (e.g., class, SOEP), (3) criteria for determining success, and (4) the resources, including aides or peer tutors, materials, resource teacher, etc., that will be needed to accomplish

each teaching-learning task. Although IEP's are not required for disadvantaged and limited-English proficiency learners, it may be helpful to form IVEP teams with remedial reading teachers, language or bilingual education teachers, counselors or whomever is appropriate.

4. *What information is needed?*

You can learn about the special needs student in the IEP/IVEP meeting. You need the information to participate productively in discussions and to plan your instruction later. Questions for which you will need answers are:

* What can the student *now* do?
* What does the student like to do? In particular, what are the person's occupational interests.
* How does the student learn best?
* What are realistic occupational goals for the student at this time? (Occupational goals can be modified upwards at a later time.)

You can help the IEP and IVEP team by providing information on:

* Occupations and employment trends in agriculture and agribusiness.
* Competencies, including basic academic skills, necessary to become employable in specific occupations.
* Competencies that can be learned in Ag II which relate to those occupations.
* Resources and support services that you would need so that the student can learn specific occupations.
* Potential SOEP or cooperative work experience sites.

5. *How do you teach a special needs student?*

Based on an IVEP you should already know:

* The occupation or groups of occupations the student is preparing for.

* The competencies that the student should learn in Ag II.

* The student's abilities, interests and preferred learning modes.

Knowing these things, teaching now becomes a matter of *creative problem solving*. Described below are a few simple steps to develop instruction and examples that apply those steps. In the examples, the occupation for which the special needs student is preparing is *greenhouse grower*. The competency which will be used in the examples is: "Prepare rooting media" (this competency would have been listed in the student's IVEP).

(1) *Identify the learning steps that the student should complete to attain each competency.*

For our example special needs student, you feel that four learning steps should be specified: (1) screen media, (2) sterilize mixed media, (3) fill pots and flats, (4) apply fertilizer to media. The specification of these four instructional steps are based on the student's abilities. Each of these learning steps can be broken down further into smaller steps; the extent to which you need to break down competencies and learning steps depends on the student's abilities. The less able the student, the more you ought to break down competencies into learning steps.

(2) *Identify the appropriate unit(s) in this guide for each competency and/or learning step.*

The *Horticulture* unit seems to fit the bill for our example student.

(3) *Analyze the teaching aides, student activities, instructional materials (including overhead transparency masters), and unit tests suggested in this guide which relate to the competencies and learning steps.*

Reading materials on preparing rooting media appear in a variety of places in the guide (pages K-8, K-12, K-15, and K-17). The introductory information at the bottom of page K-8 has reading difficulty index of grade 10.8 using the FOG method. If scientific and technical words are discounted, the readability index falls to grade 9.2. Other things that students could do is highly activity oriented, that is, hands on. Unit tests are not provided; therefore, you will use performance

tests to determine whether or not the student can prepare rooting media.

(4) *Use the suggested activities, materials and tests OR modify them so that they are appropriate for the student OR select other more appropriate methods, materials and testing procedures based on the student's abilities and how s/he learns best.*

Suppose our example student is deaf or hearing impaired but is able to read the materials. The suggested activities and materials would be appropriate. During demonstrations, however, you may need to use an interpreter if appropriate. Regardless, make sure that the student can see you clearly. Also, make sure you are not talking and showing at the same time; the student may not be able to "listen" and watch you and the interpreter at the same time. You may wish to discuss with the student the best ways to communicate when you first meet as well as periodically thereafter.

Now as another example, the student is mentally retarded with a third-grade reading level. You also know that this student will work under relatively close supervision on the job and can receive oral instructions. The person also has difficulty assimilating concepts and learns best through actual practice with many repititions of a task. The suggested reading materials may be inappropriate for this student. You may wish to include the student with other students when you demonstrate the preparation of rooting media; however, individualized instruction will more than likely be needed. Instructional aides, peer tutors and "buddies" could be very useful for the individualized instruction.

As a final example, the student is "normal" but has not learned to read adequately. The student can read at approximately the sixth grade level, but the suggested material in this guide are written at the 9.2 grade level. Knowing the student's occupational goals, even if tentative, is critical. If the group of occupations for which the student is preparing requires a reading ability of grade six, then alternative means should be provided so that the student can learn the information in the suggested materials without reading them. If, on the other hand, the occupations require grade 9.2 or higher reading ability, then the student should learn to read at that level. The suggested materials in the unit could be used as a medium through which the student can improve reading competence. You can help the student.*

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* *A Methodology for Reading Skill Improvement in Vocational Secondary Programs* has many hints on how you can help special needs students to learn to read. Copies of this document is available from your regional vocational education coordinator and the Division of Vocational Education, Oregon Department of Education.

(5) *Assure that the student has acquired each competency.*

The students in our examples, regardless of handicap or disadvantagement, need to perform every competency specified in the IVEP to the level of quality required by employers. Incompetence in the student should neither be tolerated by you nor expected by the employer. However, testing should be fair; expect what an employer should expect -- performance under realistic conditions. For our example, close supervision will be provided to the mentally retarded student on the job; realistic supervision should also be provided during the testing. You may also need to retest periodically to assure that the student maintains competencies.

6. *How do you use aides, peer tutors, and resource teachers?*

It usually requires more personnel time in one form or another for special needs students to acquire necessary competencies than it does for other students. Specifying who can best provide the additional time should have been accomplished during the development of the IEP and/or the IVEP.

Special needs students should work with a resource room or remedial reading teacher or other persons in your school *with your close cooperation.* Effective interaction with other teachers, counselors and specialists in your school may need to be developed. A sense of mutual trust and respect between you and other persons working with the student, such as the resource room teacher or the remedial reading teacher, is a necessity. You can help them when they work with special needs students on occupational competencies, including the basic academic skills needed to function on the job. They can serve as a wealth of information and ideas to you on appropriate teaching methods and techniques for a special needs learner. Are you willing to take the first step towards developing effective relationships?

Special needs students should work with aides and peer tutors in your classroom on labs *under your supervision.* Aides and peer tutors should be prepared to work with special needs students. They

should be informed of the occupational goal for the student. Then, for each competency, you should inform them of the learning steps and show them how to teach each one. You should periodically check the progress being made and confirm what the aides or tutors are doing. As an alternative, you may wish to work directly with the special needs students when needed. During these periods, it may be appropriate for aides and peer tutors to work with the other students in your class.

7. *What if the student attains all of the competencies listed in the IVEP and is capable of learning more?*

A meeting of the IEP/IVEP team is imperative. It may be advantageous to increase the number of competencies that the student can learn in Ag II for the occupation(s) previously identified. It may also be possible to increase the number of occupations for which the student is being prepared.

8. *Where can I get advice and assistance on working with special needs learners?*

Your first source of assistance and advice should be the district's vocational or special education administrator. The regional vocational education coordinator in your county's ESD is another source of advice and assistance on teaching special needs learners. Your regional coordinator should also be able to help you with developing IVEP and instructional teams within your school. If neither types of persons are available to you, contact the Agricultural Education Program at Oregon State University (phone: 754-3681) or the Vocational Education Special Needs Project (phone: 754-2586) for assistance with specific teaching methods and materials and with forming IVEP teams in your school.

Eliminating Sex Bias in Vocational Agriculture Class

Another goal of this curriculum guide was to assure that there was no sex-bias or sex-role-stereotyping in vocational agriculture classes. The following article by Paula Diperna entitled "Up On The Farm" was included so that the Vocational Agriculture teacher may use it to help students understand the problems of sex-bias and sex-role-stereotyping and as a recruiting tool to encourage young women to enter agricultural occupations.

Every effort has been made to remove sex-bias from the curriculum material contained in this package. As the instructor develops material to supplement this curriculum guide to meet local/regional needs they are encouraged to avoid sex-bias/sex-role-stereotyping.

Up On The Farm

by Paula Diperna

Most cityfolk tend to be naive about life down on the farm. They think of cows mooing, pigs oinking and chickens scratching around the barnyard. They also harbor images of farm women with their hair in buns, doing little more than churning butter and organizing quilting bees. However persistent these preconceptions are, reality simply does not bear them out. Agriculture is a complex and demanding science, offering a wide variety of career opportunities, and women are participating at every level in unprecedented numbers. Women now own farms, manage farms, loan money to farmers, promote farm products, write about farms, lobby farm issues, sell farm equipment and supplies, teach farming techniques, run farm machinery, plant, landscape, milk, work livestock and harvest crops. Female attendance at agricultural colleges has jumped radically, with some schools reporting 100 percent increase in just a few years' time. Today, women make up one-third of the undergraduate agricultural enrollment. The word is out--women on the farm are anything but down.

FEMALE FARM LABOR: THE BACKBONE OF AMERICAN AGRICULTURE

Women have been integral to the American agricultural process since the first seeds were sown in the new colonies. Farming then was a family proposition, and the farm woman usually was a wife who ran the household and pitched in with the chores--the stoic, hard-working, invariably dependable backbone of the family--farm unit. In fact, without female agri-labor, the rapid development of American agriculture never could have taken place.

It is interesting that women have always performed a wide variety of farm duties. Sherry Thomas, a former sheep rancher and coauthor of Country Woman: A Handbook for the New Farmer, is currently compiling an oral history by interviewing women who've been involved in agriculture for years. "I'm seeing that what is often regarded today as 'strange' behavior for women--like heavy farm work--has always been acceptable on the farm itself." Indeed, farm magazines in the less-than-liberated early 1900s ran numerous articles with titles such as "Beekeeping for Women"; "Three Women Who Make Mammoth Bronze Turkeys Pay Well"; "The Mistress of Overlook Farm." In 1907, a lengthly article in Farm and Fireside magazine explained: "Of late years, a constantly increasing number of women have graduated into the ranks of independent farmers, owning or leasing farms on their own responsibility and personally superintending every detail, from the purchase of the seeds to the marketing of the produce. The pioneers...are the widows of practical farmers [but they] have been joined in

many localities by other women who have migrated from cities and towns...simply because they were convinced that the work would prove more congenial than any of the other occupations open to women."

These words might just as well have been written today about the many women actively involved in farm production, who have to be part scientist, part business whiz, part magician--and plenty on the ball.

TODAY'S WOMEN FARMERS:
SHREWD AND PROFESSIONAL,
365 DAYS A YEAR

Kaye Fisher and Margaret (Maggie) Fessard, for example, run a 272-acre dairy farm in upstate New York with 100 head of registered Holstein cattle. The farmhouse is at least a century old, and the farm itself originally belonged to Fisher's grandfather. Fisher grew up on it and was right-hand helper until she went off to become a biology teacher. After two years in the classroom, she went back to take over the farm because she "just felt that was where I wanted to be." Fisher was not formally prepared for her new role. "There was a lot of things I'd never bothered to learn, or that my father hadn't bothered to teach me because nobody expected that eventually I'd be running the place." Fessar, also a teacher, and a city woman with absolutely no farming background, came down for a summer to visit and stayed on, learning by trial and error. Her initiation rite was to disc, or break up, a 40 acre pasture--a job considered to be one of a farmer's toughest on a tractor. She did it with no mishap. "I figured if I could do that, I could do anything," said Fessard.

Despite their lack of theoretical background, Fisher and Fessard have enjoyed considerable success. In the four and a half years they have run the farm, the milking herd has grown from 16 to 43 head. In addition, they breed cattle, board horses and grow all the feed -- except the protein supplements -- their animals consume. But admirer beware: They work extraordinarily hard.

The day, begun at 5:30 AM, 365 days a year, and ended at about 7 PM, is taken up with milking, feeding, barnyard and housekeeping, cropping, tending pasture, baling hay, etc., etc., etc. There is only one full-time worker-a male--though there are occasionally part-time workers.

The milking ritual is fascinating to watch. While Fassard cajoles the Holsteins back into the milking area from the outdoor pastures, Fisher settles them into their stalls. She barely can be seen amongst the cows -- their shoulders are about even with her shoulders. Clearly each animal has an individual personality quirk, which is jokingly catered to, and each cow is called by name. In every aspect of their operation Fisher and Fessard project

shrewd professionalism, efficiency and common sense. They have a good time, too, and so do the cows. Music is piped in during milking, and when I asked if it was for the cows' benefit, Fisher replied with a smile, "Well, we all enjoy it."

Fisher shudders at the thought of what the farm would be now if she hadn't taken it over. Not only would it have passed out of the family, also "the land would be lost, to agriculture, chopped into tiny tracts. Someone comes by almost every month to see if I'll sell off a piece." Not likely.

BEAUTIFUL OATS

Melda Snyder, of Flemington, New Jersey, has managed her farm alone for eleven years since her husband died. It's a magnificent 530-acre area, which grows corn, wheat, oats and alfalfa, and supports beef and dairy cattle. With eyes trained from years of experience, Snyder can spot a bad row of corn among fields of good ones. "Now here's a really sad bunch, but aren't those the most beautiful oats you've ever seen? I learned how to run things through osmosis, really. Clifford and I always made decisions together, so when the time came, I knew enough about the farm to keep it going."

Today, in addition to managing her farm, Snyder is vice-president of the New Jersey State Board of Agriculture and is a prime mover and shaker for farmers in the area. Though she is mainly concerned with farm management, she is still not above driving the hay wagons, and she radiates a farmer's free spirit and self-sufficiency. "People wonder why we farmers are so independent; well, it's a great relief to know you can grow your own food, if necessary."

Though Snyder holds a variety of degrees, has studied architecture and managed school systems, she said of her farm life style. "I simply couldn't live any other way and be happy."

GREENGROCERIES

From North Carolina, Dorothy MaClean Slade drives to New York City every week with her family to sell their produce in the flourishing Greenmarket. She apprears to love chatting with the shoppers who crowd the farmers' stalls, thrilled with the opportunity to buy directly from the farm. Her family has owned their farm for 40 years, and though Slade intended to be a nurse, she had to drop out of school for financial reasons and since has made a success of 300 cleared acres of land. "We grow everything you can name and love doing it. If my daughters want to take over the farm, that's great with me."

BIODYNAMIC FARMING

Of all these women, Anne Mendenhall has been actively farming the longest. She owns 280 acres near Aurora, New York and she capsulizes her 20-year career into a few lively

sentences: "In 1958, I left my Madison Avenue ad-agency job and came up to Cornell to study farming. I lived on a poultry farm and got a scholarship to put myself through school. One of my professors told me that Iowa was a farmer's promised land, that it had the best of everything. So off I went. When the best of everything eluded me, I came back to the Itahaca area. This place has been owned by a professor; he died, and his wife decided to sell it. I didn't have any money to put up, but she sold it to me on faith; I've been here ever since." Today, Mendenhall champions biodynamic farming and brings skeptical neighbors around to see the results she has obtained by using no commericial fertilizers or pesticides whatsoever. When we pulled up alongside her field of soy beans in neat, full, green rows, one male neighbor took a long, thoughtful look and said, with undeniable respect in his voice, "Well, I am impressed with those beans."

THE HIGH COST OF FARMING: HOW WOMEN ARE BEATING IT

Owning and operating a farm these days is far from simple, for men or women. Because land prices are now almost prohibitively high, most women who own their land have either inherited it or "married it." Equipment and supplies can run into thousands of dollars per year. In return for enormous capital and labor investment, the farmer receives a fraction of what the consumer spends on the food. Wheat growers argue, for example, that their grain pays them an amount equal to what it costs just to wrap loaves of bread in paper. Despite the odds, women who really want to farm can do so even without owning one. Some women, such as recently graduated Janet Gorst of upstate New York, job-hunt for farm work the way other women scout positons in business. Said Gorst: "My boss wanted someone who could do the job and was willing to learn new techniques. I tractor seed, do everything that I want to do."

Other women have joined in groups, like those who operate Critter Acres Farm in Penngrove, California. Cheryl Perry, who built up the business, rents land and leases a dairy along with two women friends, one of whom still holds down another job in order to pay farm bills. The farm produces goat milk and, so far, has held its own.

FARM - WOMEN'S LOBBIES: "IT'S ABOUT TIME WE HAVE SOMETHING!

In addition to farms actually run by women, there is an extraordinary upsurge in activity on the part of farm wives. Nancy Smidle of Kewauneed, Wisconsin, for example, convened American Agri-Women (AAW) for the first time in 1974. "It was about time we women had something, she said. "Most farm women know farm operations as well as' the men do." AAW, which now has 32 state chapters, 3,000 individual members and a total of 30,000 members--if you include affiliated

women's organizations--serves as a powerful farm lobby. Other women's groups abound, and the newly formed Washington-based Rural American Women (RAW) has a task force at work developing action resolutions for women's agricultural issues.

Pursuing agricultural careers is not without the obstacles inherent when women chart paths previously assumed to be in the male domain. "You always have to work doubly hard to show you can do it," said one agriculture student. "Sometimes you get the feeling that the men don't really want you touching that valuable equipment," said another. Fisher suspects that her neighbors, who now are very supportive of her, originally believed she'd be out of business within a year. Other farm women complain that male workers have difficulty taking orders from females: "It's that Latin macho-American style," said one.

Women are proving by doing, though some hurdles require more concerted action. One of the primary focuses of women's lobby groups has been to challenge farm estate-tax laws. As written in most states, these laws view farm wives as the heirs of their husbands, not as their legal partners. Often, the death of a husband means a wife is liable for estate taxes, which could mean selling off the farm in order to pay them. Yet if a wife dies, no estate taxes are owed by the husband.

Legal convolutions vary from state to state and all farm women are advised to check their legal status and to plan estate transitions carefully. Joan Adams of Buffalo, Oklahoma, current president of AAW, said: "Unless a wife keeps a separate bank account and shows in dollars and cents what she has put into the farm, her work contribution means nothing to the IRS."

AGRICULTURE SCHOOLS AND
FARMERS' GROUPS: WOMEN ARE
GETTING PARITY

Colleges around the country are reevaluating their agriculture programs to provide curriculum equity for women, and Colorado State University held a recent conference expressly for that purpose. Well-established programs are also reflecting the new female ranks. Last summer, the Black Agriculturalists-a student group at Cornell's College of Agriculture and Life Sciences-operated a community garden for the Greater Ithaca Activities Center with an all-female staff-five young women, not all of whom had farm backgrounds. Witness Dinah Torres of Valley Stream, New York, who enrolled at Cornell because "agriculture has always seemed like a good thing to me."

This year, Cornell's entering class was 50 percent female, compared with 27 percent in 1967. Leslie Dines, who did her undergraduate work in envirnomental science and has general agricultural knowledge, was the college's first female recruiter. Her genuine enthusiasm and considerable energy make you wish you'd thought about an agri-

culture career yourself. To quote Dines, "If the 'hands-on' production farming seems too strenuous or demanding, there are many other routes to go. We are seeing women entering programs all across the curriculum."

Judy Massapny, director of information for the National Grange, agreed. "I don't know if we can say that more and more women are going into farming for themselves, but we certainly see many more women in the agriculture media, in sales promotion, in the research sciences and in the agri-businesses."

Almost no group attests to the growing role of women in agriculture as clearly as Future Farmers of America (FFA), an organization of high-school students preparing for agricultural careers, which for years actually barred women from entering. (They used to sneak in by registering with first initials only.) In 1969, reacting to the general pressure of the women's movement, the group opened its ranks to women, and today, approximately 15 percent of the 508,000 membership is female. Julie Smiley, who intends to make a career in agricultural journalism, was the first female national officer of FFA, followed by Peg Armstrong, a farmer national vice-president. Ten of the organization's 50 state presidents are female.

At a caucus of the young women delegates attending the group's recent conference in Washington, DC, nothing was as obvious as the diversity of their backgrounds. Some were born to the farm, but many others were city kids transplanted to the country, or ones who had chosen agriculture on their own. Each had an equally confident perspective: "Well, the time has come for women in agriculture, that's all," said one. "We can run things better than men, and they know it." quipped another.

President Carter, who had been an FFA member as a young man in Plains, spent 20 minutes with the entire FFA delegation at a special Rose Garden reception. He talked genuinely of their mutual love of the land, then shook hands and chatted with the delegates. One girl said the President looked slightly suprised to see her but, recovering, talked to her "farmer to farmer."

NEW RESPECT FOR AGRICULTURE:
WOMEN ARE MAKING IT HAPPEN

Perhaps the most exciting aspect fo the women's movement in agriculture is the potential it has to draw together urban and rural people. As America begins to notice agriwomen, it must begin to pay more careful attention to agriculture in general. The recent farmers' strike, consumer resistance to higher food prices and rising concern with food quality and food shortages have focused attention on the agricultural segment of the economy as never before. Jean Tetrault, coauthor with Sherry Thomas of Country Woman, predicts all this attention could lead to a "renaissance of the small farm." Perhaps she is overly optimistic, but at least we know that if women have anything to do with it, there will be a new respect for and appre-

ciation of agriculture.

As Jill Beckman of Elgin, Nebraska expressed it, "I'd just like to say that I'm glad your're doing this article, because I grew up being embarrassed to say I lived on a farm." One hopes these insecurities are long in the past of American farm women. After all, if intelligent, dynamic women have chosen agriculture as a viable career alternative, there's assuredly more to it than ee-i-ee-i-o.

CAREERS IN FARMING

AGRICULTURAL PRODUCTION-THE REAL NITTY-GRITTY

Be warned. This aspect of farming is not for everyone. The hours are long, the work arduous and the financial rewards of a small farm are erratic and meager at first. Success is possible, but those who farm do so more for the sheer exhilaration of seeing things grow, for the thrill of being close to the land, than for the money that could be in it.

Credit

Though no real data on the subject exist, access to credit to start a farm should be as available to women as to men. In addition to commercial-bank loans (the American Banking Association reports that there are at least 40 female agricultural loan officers around the country), the federal government provides agricultural credit through the Federal Land Bank System, the Cooperative Farm Credit System and the Production Credit Association. For information write:

The Farm Credit Administration
Washington, DC 20578

Education

Learn about the aspect of farming that most interests you and, as Anne Mendenhall recommends, "take little steps first." All the land-grant colleges-schools which were set up in the 18th century to disseminate higher education-have schools of agriculture. There is a land-grant college in every state, and each one operated an extension service to provide outreach information from the colleges to interested farms. For information, write the land-grant college in your state.

AGRICULTURE-RELATED CAREERS

Here, the possibilities are numerous, not only for learning new skills, but also for applying old ones. Most of these jobs offer wide administrative, managerial and creative challenges. They include:

Agricultural Engineering - soil science, machinery design, farm waste management.

Agricultural Economics - farm management, business manage-

ment, international economy, agri-banking.

Agricultural Science - biology, botany, ecology, genetics, breeding, forestry, animal science, equestrian science.

Environmental Science - landscape architecture, aquatic and atmospheric study, natural-resource management.

Food Science - nutrition, food analysis.

Plant Science - vegetable crops, field crops, horiculture, pomology, ornamental horticulture, floriculture, plant breeding.

Sociology and Behavior, Communicatons - rural studies, agri-journalism, product marketing, sales promotion, data collection.

Agricultural Education - teaching agricultural subjects.

For more information on careers in agriculture, write the college of your choice or:

National Association of Land-Grant Colleges
One Dupont Circle
Washington, DC 20036

PUBLICATIONS

The Department of Agriculture publishes numerous brochures on every aspect of agriculture, many of which are free. Write:

US Department of Agriculture
Publications Division, CPA
Washington, DC 20250

Also order a copy of the 1978 US Department of Agriculture Yearbook, entitled Making It on a Few Acres, from:

Superintendent of Documents
Government Printing Office
Washington, DC 20402

Another fine source of practical farming tips is Country Woman, by Sherry Thomas and Jean Tetrault, Anchor Press, 1976, $6.95.

Planned Course Statement

Department: Vocational Agriculture

Course Title: Agriculture II (_____)
Alternate Title
(for the imaginative)

Course Number: _____

Length of Course: 36 weeks No. of Credits: 1 Grade Level: 10

Prerequisite: Ag I Credit by Exam Available [ ]yes [ ]no

Check one:
[ ] Required
[ ] Selective
[ ] Elective

Alternate Learning Opportunities (check one or more)
[ ] Does Not Apply
[ ] Independent Study
[ ] Off-Campus Experience
[✓] Other (Explain in Course Overview)

Course Overview: The course will provide students who have a career interest in agricultural occupations fundamental concepts and skills necessary to explore and begin specific employment questions. Classroom instruction will be combined with laboratory activities, leadership activities, specific occupational activities and the Future Farmers of America (FFA) activities to enhance learning. Supervised Occupational Experienced Programs (SOEP) in the form of on the farm projects, cooperative work experience in agriculture, supervised laboratory experience, agricultural services projects, and/or farm and/or homestead improvement projects are required of those students who participate in Agriculture II for the purpose of developing on-the-job skills and refining tentative career choices.

Program Goal at Agriculture II Level:

The student will:

1. Understand and explore basic agricultural principles and careers which impact production agriculture and agri-business occupations in the employment region served by the high school.
2. Begin preparation for entry into agricultural occupations in production agriculture and agri-business through the study of specific subject matter contained in the Agriculture II guide.
3. Make tentative career choices based on their abilities, aptitudes, interests, and values.

Course Objectives:

Upon completion of Agriculture II the student will be able to:

1. Plan for farm fence construction.
2. Purchase appropriate materials and construct a sound farm fence.
3. Understand and explain soil morphology as it relates to crop production.
4. Determine correct fertilizer application amounts for given soil-crop relationships.
5. Judge soils.
6. Describe animal digestive systems.
7. Identify animal nutrient requirements and sources of nutrients.
8. Develop rations for feeding livestock.
9. Use appropriate depreciation schedules for agricultural applications.
10. Complete a set of farm records.
11. Analyze records for economic efieciency.
12. Function in a meeting following correct parliamentary procedure.
13. Chair a meeting using correct parliamentary procedure.
14. Perform out-of-position welds with Arc and Oxygen-Acetylene welding equipment.
15. Develop a preventive maintenance schedule for farm machinery.
16. Perform correct preventive maintenance activities on farm machinery.
17. Know production practices and sequencing for cereal crop production.
18. Know production practices and sequencing for forage crop production.
19. Asexually propagate various ornamental plants.
20. Prune various trees and shrubs.
21. Perform common livestock care skill such as: castrate, dehorn, brand, dock, and vaccinate.
22. Correctly handle livestock using proper restraints.

Learning Activities:

1. Individual and group projects.
2. Group discussions.
3. Teacher and resource person presentations.
4. Student presentations.
5. Problem solving activities.
6. Field trips to local Farms, Ranches, Agri-business, and Agricultural Shows and Fairs.

7. Viewing slides, films, and filmstrips.
8. Participation in classroom, district, sectional, state and national contests.
9. Completion of worksheets and study guides.
10. Participation in FFA meetings, activities and contests.
11. Participation in SOEP.
12. Keep accurate records of SOEP.
13. Participate in decision making process as applied to instructional areas and goal setting throughout the course.
14. Setting tentative occupational goals in agriculture and working toward them -- revising the goals as appropriate and changing direction.

Assessment Procedures:

1. Written and oral assignments.
2. Individual and group projects.
3. Written and performance tests.
4. Notebook of instructional material.
5. SOEP evaluation.
6. Observation by teacher.
7. One-to-one conferences between teacher and student.

Advanced Planning for Course

Some instructional materials must be ordered in the summer inorder to have them on hand when needed. Below is a list of early planning considerations.

1. Order films in June-July or earlier. Major free loan film companies are:

   a. The Farm Film Foundation
      1425 H. St., N.W.
      Washington, DC 20005

   b. Modern Talking Pictures Service, Inc.
      #16 Spear St.
      San Francisco, CA 94105

   c. Vernard Films Ltd.
      Box 1332
      Peoria, IL 61601

   d. Educational Films
      The Farm Credit Banks of Wichita
      151 North Main
      Wichita, Kansas 67202

   e. Safer Oregon
      Worker's Compenstaion Department
      Accident Prevention Division
      Labor and Industries Bldg.
      Salem, Oregon 97310

Write and get catalogs from these firms and place orders early. Instructional materials available include charts, pictures, informational data, films, and film strips.

1. Allis-Chalmers
   Ideal Pictures Film Library
   4431 West North Ave.
   Milwaukee, WI 53208

2. Amchem Products, Inc.
   Agricultural Division
   Advertising Department
   Ambler, PA 19002

3. American Cyanamid Co.
   David Butterfield
   Agricultural Division
   P.O. Box 400
   Princeton, NJ 08540

4. American Farm Bureau Federation
   Information Division
   225 Touhy Ave.
   Park Ridge, IL 60068

5. American Quarter Horse Assn.
   Film Reservations
   2736 West 10th,
   Armarillo, TX 97168

6. American Sheep Producers Council
   200 Clayton
   Denver, Colorado 80206

7. Armco Steel Corporation
   Training Division
   7000 Roberts St.
   Kansas City, MO 64125

8. Audio Visual Productions, Inc.
   1233 N. Ashland Ave.
   Chicago, IL 60622

9. BASF Wyandotte Corporation
   100 Cherry Hill Road
   Parsippany, NJ 07054

10. Babson Bros.
    Babson Bros. Company
    2100 South York Road
    Oak Brook, IL 60521

Addresses Continued:

11. Blue Anchor, Inc.
Walter Tindell
P.O. Box 15498
Sacramento, CA 95813

12. JI Case Co.
Ag. Equip. Division
700 State Street
Racine, WL 53404

13. Caterpillar Tractor Co.
100 N.E. Adams
Peoria, IL 61629

14. Deutz Corporation
7385 Pounce de Leon Circle
Atlanta, GA 30340

15. Dickey-john Corporation
Films
P.O. Box 10
Auburn, IL 62615

16. Dow Chemical U.S.A.
Film Library
P.O. Box 1706
Midland, ML 48640

17. E.I. Du Pont & Co.
Advertising Department
Audio Visual Section
Wilmington, DE 19698

18. Elanco
Annette Proctor, Film Library
Eli Lilly & Co.
Indianapolis, IN 46206

19. Elliott Films
2635 Nicollet Ave.
Minneapolis, MN 55408

20. Energy Film Library
DOE Technical Info Center
P.O. Box 62

21. The Farm Film Foundation
1425 H. St. N.W.
Washington, DC 20005

22. Farmbank Services
Joe Basher
12000 E. 47th Ave.
P.O. Box 39088
Second Floor
Denver, Colorado 80239

23. The Fertilizer Institute
1015 18th St. N.W.
Washington, DC 20036

24. Gehl Company
Marketing Services
143 Water Street
West Bend, WI 53095

25. Golden Harves Seeds, Inc.
Charles R. Finley, Exec. VP
513 E. Locust St.
Bloomington, IL 61701

26. Grain Terminal Association
P.O. Box 43594
167 Snelling Ave. N.
St. Paul, MN 55164

27. Grinnell Mutual Reinsurance Co.
Public Relations Department
1-80 at Highway 146
Grinnell, IA 50112

28. Gulf Oil Corporation
Public Relations Department
Gulf Building
Pittsburgh, PA 15230

29. Holstein-Friesen Association
Box 808
Brattleboro, Vermont 05301

30. ICI Americas Inc.
Wilmington, DE 19897

31. International Minerals &
Chem. Corp.
Audio Visual Department
501 E. Lange Street
Mundelein, IL 60060

32. International Harvester
Route 71 & Harvester Road
Sheridan, IL 60551

33. Iowa Farm Bureau Federation
Wendall Jarvis, Creative Visuals
5400 University Ave.
West Des Moines, IA 50265

34. University of Iowa
Media Library
Iowa City, IA 52240

35. Kalo Laboratories, Inc.
9233 Ward Parkway
Kansas City, MO 64114

Addresses Continued:

36. Lindsay Manufaturing Co.
Russ Carlton, Adv & Promotion
Box 156
Lindsay, NE 68644

37. University of Maryland
Audio-Visual Services Dept.
Annapolis Hall
College Park, MD 20742

38. Modern Talking Picture Service Inc.
Rosanne Pollack
5000 Park St. N.
St. Petersburg, FL 33709

39. Monsanto Ag. Products
Larry Evetts
800 N. Lindbergh Blvd.
St. Louis, MO 63166

40. Nat. Cotton Council of Amer.
P.O. Box 12285
Memphis, TN 38112

41. Nat. Rural Electric Coop. Assn.
2000 Florida Ave. N.W.
Washington, DC 20009

42. North Dakota St. Film Library
North Dakota State University
Fargo, ND 58102

43. Occidental Chemical Co.
Public Relations Dept.
P.O. Box 196
Lathrop, CA 95330

44. Owatonna Man. Co., Inc.
Bob Duncan
P.O. Box 547, Hwy. 45 N.
Owatonna, MN 55060

45. Ralston Purina
Checkerboard Square
St. Louis, MO 63188

46. Roche Chemical Co.
340 Kingsland St.
Nutiey, NJ 07110

47. Rohm and Haas Company
Librarian
Independence Mall West
Philadelphia, PA 19135

48. Shwartz Manufacturing,
Division of Chromalloy
129 Pine St. South
Lester Prairie, MN 55354

49. Select Sires Inc.
11740 U.S. 42
Plain City, OH 43064

50. Shell Firm Library
1433 Sadlier Circle W. Dr.
Indianapolis, IN 46239

51. Sioux City Livestock Market
News Foundation
128 Livestock Exchange Bldg.
Sioux City, IA 51107

52. Smith Kline Animal Health
Karol Media
933 Pacific Avenue
Kansas City, MO 66101

53. Bill Snyder Films, Inc.
Box 2784
Stoneville, MS 38776

54. Soil Enterprise Corp.
P.O. Box 128
Stoneville, MS 38776

55. Sperry New Holland
Public Relations Department
New Holland, PA 17557

56. Steiger Tractor Inc.
Box 6006
3101 1st Ave. North
Fargo, ND 58102

57. Tri-State Breeders Cooperative
Director of Public Relations
Westby, WI 54667

58. The Upjohn Company
Corporate Film Library
7000 Portage Road
Kalamazoo, ML 49001

59. USS Agri-Chemicals
Alan Kendall
P.O. Box 1685
Atlanta, GA 30301

60. Vermeer Manufacturing Co.
Jaap Kroes
Box 200
Pella, IA 50219

61. Washington State University
Instructional Materials Center
Pullman, WA 99164

Addresses Continued:

62. White Farm Equipment
Merchandising Department
2625 Butterfield Road
Oak Brook, IL 60521

2. Get current commodity date information sheets. Annually updated sheets are available in January from:

Stan Miles
219 Extension Hall
Oregon State University
Corvallis, Oregon 97331
(Phone 754-4821)

a. Get both, "Oregon's Leading Agricultural Commodities" and "Oregon Gross Farm Sales Preliminary Estimates".

b. Copies of 1981 data sheets are included in this packet as examples. Get up-dated sheets each January.

OREGON'S LEADING AGRICULTURAL COMMODITIES

Gross Farm Sales

1981

Rank	Commodity	1981p	1980r	1979
		thousand dollars		
1	Cattle & Calves	304,769	290,000	360,000
2.	Wheat	302,153	301,860	210,254
3.	Dairy	172,466	151,472	133,327
4.	Potatoes	96,999	83,489	63,830
5.	Nursery Crops	91,140	85,500	1/
6.	Alfalfa Hay	49,454	49,171	36,500
7.	Farm Forest	39,100	47,815	50,411
8.	Dry Onions	38,005	30,645	12,366
9.	Chicken Eggs	31,757	27,316	27,035
10.	Perennial Ryegrass	30,020	24,325	21,602
11.	Annual Ryegrass	27,438	23,485	19,291
12.	Barley	26,631	25,812	17,263
13.	Winter Pears	25,929	24,240	26,880
14.	Christmas Trees	25,563	20,610	15,574
15.	Broilers	24,661	23,342	23,251
16.	Peppermint	22,868	24,300	26,163
17.	Sweet Corr, Processed	22,079	17,902	20,216
18.	Sweet Cherries	20,777	15,900	20,672
19.	Snap Beans, Processed	20,647	24,714	26,380
20.	Sheep & Lambs	20,000	16,142	16,500
21.	Strawberries	19,918	15,333	14,370
22.	Hops	18,475	17,371	9,228
23.	Hogs	17,254	16,309	15,827
24.	Greenhouse Crops	17,115	14,899	1/
25.	Apples	15,532	14,820	18,700
26.	Filberts	13,920	17,380	12,078
27.	All Kentucky Bluegrass	11,170	11,642	10,214
28.	Turkeys	10,774	10,004	10,552
29.	Horses	10,166	7,447	6,918
30.	Sugarbeets for Sugar	8,800	9,176	4,550
31	Dry Field Beans	8,561	5,656	2,280
32.	Green Peas	8,478	9,363	7,595
33.	Oats	8,081	6,319	4,681
34.	Corn for Grain	8,072	2,436	2,114
35.	Bartlett Pears	7,373	13,600	14,620
36.	Hay (Other than alfalfa)	7,066	7,500	6,252
37.	Mink	6,669	5,958	5,620
38.	Bentgrass	6,498	6,854	8,550
39.	Sugarbeets for Seed	6,470	4,312	3,010
40.	Red Raspberries	5,791	2,979	6,820

p - Preliminary r - Revised. 1/ not estimated separately.

Rank	Commodity	1981p	1980r	1979
		thousand dollars		
41.	Red Clover	4,967	4,032	3,940
42.	Vegetables and Flower Seed	4,611	3,688	4,223
43.	Orchardgrass	4,556	6,792	6,120
44.	Chewings Fescue	4,489	7,075	5,184
45.	Tame Blackberries	4,419	5,875	8,162
46.	Turf Sod	4,340	5,215	1/
47.	Corn Silage	4,153	4,527	3,943
48.	Red Fescue	3,846	4,200	3,848
49.	Cranberries	3,553	2,722	2,523
50.	Prunes & Plums	3,527	4,983	4,784
51.	Peaches	3,480	2,899	3,072
52.	Bulbs	3,425	3,195	2,893
53.	Alfalfa Seed	3,366	5,415	5,166
54.	Cucumbers. Processed	2,907	2,712	2,374
55.	Crimson Clover	2,846	1,433	2,300
56.	Grapes	2,835	2,091	1,734
57.	Wool	2,797	3,220	3,210
58.	Squash & Pumpkins	2,584	2,029	1,800
59.	Blueberries	2,538	1,400	1,572
60.	Tall Fescue	2,518	2,618	1,872
61.	Cauliflower, Processed	2,480	2,895	2,381
62.	Dry Field Peas	2,469	2,628	2,613
63.	Cabbage	2,421	2,094	1,620
64.	Turkey Eggs	2,346	2,459	2,154
65.	Sweet Corn, Fresh	2,216	2,225	2,138
66.	Beets, Processed	2,011	1,927	2,067
67.	Lettuce	1,958	1,862	1,667
68.	Cauliflower, Fresh	1,811	1,500	1,254
69.	Carrots, Fresh	1,680	2,086	910
70.	Tart Cherries	1,639	1,015	1,519
71.	Broccoli, Processed	1,634	1,437	1,200
72.	Watermelon	1,570	1,280	885
73.	Spearmint for Oil	1,535	1,470	1,453
74.	Austrian Peas	1,348	1,254	1,613
75.	Honey & Beeswax	1,305	1,264	1,196
76.	Hairy Vetch	1,263	868	1,900
77.	Garlic	1,242	1,288	1,069
78.	Tomatoes	1,235	925	969
79.	Walnuts	1,225	1,425	1,444
80.	Boysenberries	1,185	1,064	1,873
81.	Pinto Beans	1,126	1,650	n/a
82.	Asparagus	1,119	582	527
83.	White Clover & Ladino	1,085	1,037	772
84.	Carrots, Processed	1,038	925	1,086
85.	Rabbits	1,027	1,011	716
Other commodities		39,602	41,738	117,590 2/
TOTAL GROSS FARM SALES		1,759,966	1,663,428	1,512,830

p - Preliminary. r - Revised.

1/ not estimated separately.

2/ includes nursery crops, greenhouse crops and turf sod.

SOURCE: Compiled by Extension Economic Information Office, Oregon State University.

OREGON GROSS FARM SALES
Preliminary 1981 Estimates

District & county	Grains	Hay & silage	Grass & legume seeds	Field crops	Tree fruits & nuts	Small fruits & berries	All vegetable crops	Specialty products	All crops	Cattle & calves	Dairy products	Eggs & poultry	Misc. animals	All livestock & products	Total gross income
	thousand dollars														
The State....	345,203	61,941	106,797	173,105	96,462	38,903	123,574	202,403	1,148,388	304,769	172,466	67,695	66,648	611,578	1,759,966
District 1...	62,556	8,127	91,323	41,976	30,012	33,127	85,637	162,968	515,156	34,775	78,505	60,245	31,453	204,978	720,134
Benton.....	4,495	468	7,005	2,494	759	725	4,621	7,325	27,892	1,890	3,780	209	1,337	7,216	35,108
Clackamas..	4,945	796	3,144	1,042	2,681	5,193	10,794	37,880	66,475	4,935	6,950	20,602	8,633	41,120	107,595
Lane.....	4,156	353	4,922	4,159	3,128	821	6,621	11,250	35,410	6,518	7,440	7,368	1,886	23,212	58,622
Linn.....	7,615	1,366	45,765	5,517	832	1,477	5,202	5,644	73,138	5,682	8,813	4,835	6,932	26,262	99,400
Marion.....	10,944	1,569	16,123	23,574	5,446	10,526	37,144	40,020	145,346	5,854	23,487	10,165	4,735	44,240	189,586
Multnomah..	556	81	98	352	144	3,523	6,347	21,297	32,398	745	1,623	10	561	2,939	35,337
Polk.....	10,787	723	5,309	3,123	3,835	863	1,712	5,545	31,897	2,497	5,167	4,537	1,655	13,856	45,753
Washington.	7,227	1,966	5,019	1,271	6,067	9,945	7,514	24,945	63,054	3,042	12,065	580	2,069	17,756	80,810
Yamhill....	11,831	1,105	3,918	444	7,120	954	5,112	9,062	39,546	3,612	9,180	11,939	3,646	28,377	67,923
District 2...	537	436	40	60	39	5,041	171	13,692	20,016	16,912	54,968	293	6,152	78,325	98,341
Clatsop....	---	66	---	---	---	58	5	1,900	2,029	1,193	2,046	8	1,874	5,121	7,150
Columbia...	537	132	40	38	21	1,320	76	3,700	5,864	3,037	2,984	8	450	6,479	12,343
Coos.....	---	99	---	---	13	3,220	10	2,677	6,019	4,873	11,583	249	1,438	18,143	24,162
Curry.....	---	18	---	---	5	341	---	2,390	2,754	1,546	891	5	1,012	3,454	6,208
Lincoln....	---	27	---	---	---	53	50	1,725	1,855	1,097	314	23	359	1,793	3,648
Tillamook..	---	94	---	22	---	49	30	1,300	1,495	5,166	37,150	---	1,019	43,335	44,830
District 3...	2,428	1,549	572	1,402	16,357	452	1,889	14,338	38,987	21,492	14,892	4,187	7,465	48,036	87,023
Douglas....	1,435	494	153	36	2,411	425	1,416	8,250	14,620	10,679	1,286	647	5,071	17,683	32,303
Jackson....	941	762	419	198	13,706	27	377	3,154	19,584	8,485	5,945	3,404	1,713	19,547	39,131
Josephine..	52	293	---	1,168	240	---	96	2,934	4,783	2,328	7,661	136	681	10,806	15,589
District 4...	219,732	13,618	1,142	60,293	48,301	267	13,036	5,710	362,099	48,449	1,691	2,168	8,861	61,169	423,268
Gilliam....	22,804	269	234	173	---	---	---	10	23,490	4,327	---	---	195	4,522	28,012
Hood River.	---	135	---	---	31,484	99	85	770	32,573	732	507	364	449	2,052	34,625
Morrow.....	49,476	6,830	---	36,900	99	---	137	1,550	94,992	8,923	436	---	1,422	10,781	105,773
Sherman....	32,306	54	---	40	15	---	---	---	32,415	1,813	---	1,795	127	3,735	36,150
Umatilla...	91,238	5,570	908	23,056	5,857	168	12,712	2,830	142,334	23,432	748	6	5,314	29,500	171,839
Wasco.....	23,404	698	---	---	10,846	---	102	400	35,450	5,740	---	3	1,051	6,794	42,244
Wheeler....	504	62	---	124	---	---	---	150	840	3,482	---	---	303	3,785	4,625
District 5...	38,957	7,107	7,676	34,445	1,474	16	22,994	2,030	114,699	84,682	15,074	24	4,679	104,459	219,158
Baker.....	3,553	1,202	43	170	20	---	---	360	5,348	18,051	2,422	3	832	21,308	26,656
Malheur....	16,268	4,012	2,202	32,503	243	16	22,967	100	78,311	51,262	11,887	10	1,493	64,652	142,963
Union.....	13,420	793	5,431	692	1,211	---	---	870	22,417	5,111	610	8	1,442	7,171	29,588
Wallowa....	5,716	1,100	---	1,080	---	---	27	700	8,623	10,258	155	3	912	11,328	19,951
District 6...	20,993	31,104	6,044	34,929	279	---	417	3,665	97,431	98,459	7,336	78	8,038	114,611	212,042
Crook.....	1,376	6,615	150	2,859	---	---	8	250	11,258	12,688	575	31	492	13,786	25,044
Deschutes..	619	1,901	113	1,253	---	---	---	950	4,836	4,215	2,371	20	1,716	8,322	13,158
Grant.....	433	882	---	374	279	---	---	1,260	3,228	9,709	---	40	1,808	11,557	14,785
Harney.....	1,110	2,848	36	132	---	---	---	10	4,136	19,207	---	---	501	19,708	23,844
Jefferson..	7,296	1,785	5,697	12,074	---	---	409	175	27,436	9,443	---	3	1,227	10,673	38,109
Klamath....	8,412	10,088	20	17,885	---	---	---	900	37,305	26,527	4,315	684	1,693	33,219	70,524
Lake.....	1,747	6,985	28	352	---	---	---	120	9,232	16,670	75	---	601	17,346	26,578

SOURCE: Compiled by Extension Economic Information Office, Oregon State University.

December 1981

HARVESTED ACREAGE SUMMARY*

Oregon Counties, 1981

Counties	Grains	Hay & forage	Grass & leg seeds	Field crops	Tree Fr & nuts	Sm Fru & ber	All Veg crops	Spec. Products	Total
State Total	1,613,000	1,118,550	339,340	155,790	79,589	15,549	125,320	2,432	3,450,512
District 1	327,800	175,100	302,030	36,170	40,803	13,388	84,954	2,032	983,702
Benton	22,400	11,900	23,600	2,850	628	225	6,806	540	68,955
Clackamas	33,300	26,200	11,100	590	3,720	2,705	5,710	520	83,845
Lane	24,300	23,300	16,600	5,730	3,800	335	9,142	100	83,365
Linn	40,800	26,400	148,950	7,665	855	550	6,940	122	232,292
Marion	54,900	22,300	45,050	15,230	6,500	4,725	41,444	270	190,415
Multnomah	3,900	3,300	400	250	140	1,300	2,475	10	11,780
Polk	54,600	14,700	21,240	2,390	5,580	433	2,795	340	102,085
Washington	35,100	25,000	18,000	1,085	10,020	3,100	3,432	100	96,740
Yamhill	58,500	22,000	17,030	380	9,560	515	6,210	30	114,225
District 2	3,550	37,300	245	90	32	1,363	120	70	42,770
Clatsop	---	4,000	25	---	---	---	---	---	4,025
Columbia	3,550	8,800	220	70	32	480	120	50	13,320
Coos	---	12,500	---	---	---	748	---	10	13,260
Curry	---	2,500	---	---	---	91	---	---	2,590
Lincoln	---	3,000	---	---	---	30	---	10	3,040
Tillamook	---	6,500	---	20	---	14	---	---	6,535
District 3	15,650	84,100	750	1,265	12,906	168	1,060	150	116,060
Douglas	10,400	47,300	270	55	2,100	155	805	90	61,185
Jackson	4,900	27,600	480	260	10,635	13	213	40	44,145
Josephine	350	9,200	---	950	171	---	42	20	10,730
District 4	952,100	124,100	2,510	45,860	24,704	125	27,826	150	1,177,375
Gilliam	139,500	7,600	480	430	---	---	---	---	148,010
Hood River	---	2,150	---	---	15,210	45	26	---	17,435
Morrow	224,750	30,700	---	27,350	40	---	80	150	283,070
Sherman	151,750	950	---	250	12	---	---	---	152,960
Umatilla	335,800	57,700	2,030	17,730	3,605	80	27,697	---	444,650
Wasco	96,600	13,000	---	---	5,837	---	23	---	115,460
Wheeler	3,700	12,000	---	100	---	---	---	---	15,800
District 5	187,300	231,100	16,285	42,100	1,010	5	11,080	---	488,885
Baker	21,300	72,600	150	330	20	---	---	---	94,400
Malheur	59,500	97,500	5,250	38,870	140	5	11,020	---	212,285
Union	69,000	31,000	10,885	2,500	850	---	---	---	114,240
Wallowa	37,500	30,000	---	400	---	---	60	---	67,960
District 6	126,600	466,850	17,520	30,305	134	---	280	30	641,720
Crook	4,900	49,000	550	2,920	---	---	---	---	57,370
Deschutes	3,650	22,700	370	1,050	---	---	---	---	27,770
Grant	2,850	46,000	---	630	134	---	---	---	49,610
Harney	16,600	131,000	1,500	120	---	---	---	---	149,220
Jefferson	30,350	17,150	15,020	15,955	---	---	280	30	78,790
Klamath	43,150	71,000	---	9,000	---	---	---	---	123,150
Lake	25,100	130,000	80	630	---	---	---	---	155,810

*Acreage estimates are not included for many specialty crops, pastures and rangeland areas.

SOURCE: Compiled by Extension Economic Information Office, Oregon State University. December 1981

3. Breed Association Addresses:

Breed association addresses are printed each year in "Agri-Educator". "Agri-Educator" is published twice yearly and can be obtained from the following address:

Agri-Educator
5520-G Touhy Ave.
Skokie, IL 60076

4. Breed Identification Slides

a. Up-to-date breed identification slides are available from:

1. Vocational Instructional Services
F.E. Box 182
Texas A & M University
College Station, Texas 77842

2. Vocational Agriculture Service
343 Mumford Hall
Urbana, IL 61801

Curriculum Validation Statement

1. A research study of Oregon manpower needs in agriculture was conducted to determine agricultural job titles which have potential for placement of high school graduates in Oregon.

2. McClays study on competencies needed by persons employed within various agricultural occupational titles was used to assess the coverage of the technical agricultural competencies contained in the curriculum guide.

3. All job titles and competencies were covered over the course of the four-year curriculum guide and thus the curriculum package (Ag I, Ag II, Ag III and Ag IV) was considered valid for use in Oregon.

4. A group of sixteen (16) Oregon Vocational Agriculture teachers formed the curriculum project advisory committee and provided guidance for scope and sequence of the materials. They also provided input for the format of the curriculum guide.

It was the feeling of the project staff that the best source of information for curriculum content and format for vocational agriculture teachers in Oregon were the vocational agriculture teachers themselves. The names of the advisory committee members were listed in the Preface of the introduction.

The Four Year Unit Outline:

The four year unit outline which was developed by the curriculum Advisory Committee as a guide for vocational agriculture instruction in Oregon follows. This guide was developed and validated using the manpower data discussed in section F of the Introduction.

CURRICULUM
for
Vocational Agriculture

SCHOOL YEAR _____ DEPARTMENT _____

TEACHER'S NAME Oregon Vo-Ag Curriculum

Week Number	Week Date	Special Events	FIRST YEAR-(1st and 2nd Semesters) Name of Course Ag I	SECOND YEAR-(3rd and 4th Semesters) Name of Course Ag II
1			-Intro. Vo-Ag Prog., SOEP, FFA	-Intro. & Records Update
2			-Tractor Operation & Safety	-Fencing (2 wks.)
3			(4 wks) ↓	-Fencing
4	Fri.	Check Record Books (except Frosh)		-Soils (5 wks.)
5				Morphology, Drainage
6			-FFA: History, Org., Programs	Testing
7			(3 Wks) Creed	Fertilizers
8	Fri.	Check Record Books (except Frosh)		Evaluation (Judging)
9			-Small Engines: Prev. Maint. and Winterization	Animal Nutrition (4 wks)
10			-Intro. to Beef: Breeds, Parts,	" "
11			Term, Selection, Thumb Rules Mgmt	Ration Formulation
12	Fri.	Check Record Books (except Frosh)	-SOEP: Decision Making - Select	" "
13			Project, Begin Record Book	Public Speaking (2 wks)
14			-Parliamentary Procedure	" "
15			(3 Wks) ↓	Record Books (2 wks)
16	Fri.	Check Record Books		" "
17			-Christmas Vacation X X X X X X X	X X X X X X X X X X X X X X X X
18			-Intro. to Sheep: Breeds ID, Parts	-Parliamentary Procedure (2 Wks)
19			Term., Selection, Thumb Rules (1½ wks)	" "
20			-Local Adaption-Animal	-Advanced Ferrous Welding (5 Wks)
21	Fri.	Check Record Books	Science (2½ Wks)	
22			-Intro. to Swine: Breeds, Parts	Arc (vertical & horizontal)
23			Term., Slec., Thumb Rules (1½ Wks)	O-A (braze, weld & cut)
24			-Shop: Safety, Skills Demo., Tool	" "
25	Fri.	Check Record Books	ID, & Basic Plans Reading	Preventive Maintenance (3 wks)
26			Intro to: Arc } 2 wks	
27			O-A }	
28			-Spring Vacation X X X X X X X X	X X X X X X X X X X X X X X X X
29			Wood Project } 2 wks	-Plant Sci: Local Adaptation
30			}	(4-5 wks) Crops (Forages & Cereal)
31			Tape & Die }	or
32			Tool Fitting } 2 wks	Horticulture
33			-Plant Sci: Local adaptation	" "
34	Fri.	Check Record Books	Crops &/or Hort.	Livestock Skills (4-5 wks)
35			(4 Wks) ↓	" "
36				" "
37			-Showing & Fitting: Beef	Appendix - Livestock Selection
38	Fri.	Check Record Books	Sheep, Swine - Close school	Appendix - Horses & Horsemanship

KEY

- ☐ Animal Science
- ☐ Soil Science
- ☐ Plant Science
- ☐ Agricultural Mechanics
- ☐ Agriculture Business Management
- ☐ Leadership and Personal Development

Number	Date	THIRD YEAR–(5th and 6th Semesters) Name of Course Ag III	FOURTH YEAR–(7th and 8th Semesters) Name of Course Ag IV
1		-Intro. & Records Update	-Intro. & Records Update
2		-Land Measurement & (2 Wks)	-Irrigation Systems (2 Wks)
3		Surveying	" "
4	Fri.	-Animal Production (6 Wks)	-Production Records (2 Wks)
5		Genetics, Breeding Programs,	" "
6		A.I., Record Keeping Systems	-Projects (6 Wks)
7		Health,	"
8	Fri.	Sanitation & Diseases	"
9		(symptoms, prevention, cure)	"
10		-Electric Wiring (2 Wks)	"
11		" "	"
12	Fri.	-Electric Motor Maintenance (2 Wks)	-Farmstead Layout (2 Wks)
13		" " "	Lighting, storage, corral
14		-Plumbing (1 Wk)	systems, & ventilation
15		-Informative Speaking	-Persuasive Speaking
16	Fri.	-Record Books	-Record Books
17		X X X X X X X X X X X X X X X X X X	X X X X X X X X X X X X X X X X X X
18		-Applications(St.Farmer, Profic.,	-Farm Taxes (2 Wks)
19		-Non-Ferrous & Repair Welding(4 Wk)	" "
20		Metal Identification	-Ag Financing, Farm Law, (4 Wks)
21	Fri.	Aluminum, Cast Iron,	Ag Agencies and
22		Hardsurfacing, High Carbon Steel	Machinery Management
23		-Preventive Maintenance (3 Wks)	" "
24		Tractors & Machinery	-Agricultural Cooperatives, (4 Wks)
25	Fri.	Hydraulic Systems	Agricultural Marketing
26		Meats (2 Wks)	(Futures, Contracts,
27		"	Open market, etc.)
28		X X X X X X X X X X X X X X X X X X	X X X X X X X X X X X X X X X X X X
29		-Plant Science: Local adaptation	-Pesticides (3 Wks)
30		(5 Wks) Specialty crops or	safety, applicator license,
31		Farm Forestry or,	equipment calibration
32		Horticulture or,	-Building Construction (7 Wks)
33		Christmas Tree Production	concrete
34	Fri.	-Harvesting Equipment (5 Wks)	building materials
35		Combines,	building nomenclature
36		Balers-Swathers,	build a small structure
37		Forage Harvestors,	" " "
38	Fri.	Specialty Equipment	" " "
		Appendix - Bees	

*Note: Career information is to be inserted in each unit as it is covered - there is no separate career unit.

ORIENTATION

Teachers Use Guide:

1. This unit was designed to help you orient students to your vocational agriculture program during the first week of class.

2. Included is a:

   a. Unit Calendar for the Ag II year
   b. Objectives for the orientation lesson
   c. Outline for the orientation lesson
   d. Vocational Agriculture Department Policies
   e. Notebook Requirements
   f. SOEP Question and Answer Sheets
   g. SOEP Policy Sheet
   h. FFA Information Sheet
   i. Classroom Management Suggestions
   j. Example: Calendar of Activities

3. You should, in the process of teaching this unit, hand out a, d, e, f, g, h, and j from the above list.

4. From Number 2 above, items f, g, and h can be used during your summer recruitment effort and also may be given or mailed to parents to help explain the vocational agriculture program and its requirements.

5. The calendar of activities should be completed prior to the opening of school. The FFA executive committee normally has the responsibility of finalizing the program of activities. A good way to complete the program of activities with maximum student input is to have a chapter leadership camp sometime during the summer months.

AG II - UNIT CALENDAR

Unit Topic	Days	Unit Section
Orientation, Records Update	5 days	II
Fencing	10-15 days	III
Soils	10-15 days	IV
Fertilizers	5 days	IV
Soils Judging	5 days	IV
Animal Nutrition	10-15 days	V
Ration Formulation	5-10 days	V
Public Speaking	5-10 days	VI
Record Books	5-10 days	VII
Parliamentary Procedure Review	10-15 days	VIII
Advanced Ferrous Welding	20-25 days	IX
Preventive Maintenance	10-15 days	X
Plant Science (either or both)	15-25 days	
a. Cereals and Forages		XI
b. Ornamental Horticulture (adjust timing)		XII
Livestock Skills	15-20 days	XIII
Livestock Selection Review	10 days	XIV (Optional Unit)
Horses and Horsemanship	10 days	XV (Optional Unit)

INTRODUCTION TO VOCATIONAL AGRICULTURE

OBJECTIVES:

Upon completion of this unit the student will:

1. Know what they will learn if they stay in Vocational Agriculture for 4 years.
2. Understand that SOEP is a requirement and a major part of the program.
3. Take information home pertinent to the Vocational Agriculture program.
4. Purchase a notebook and keep all information from Vocational Agriculture class in it.
5. Know and understand the classroom rules and school policies.
6. Understand the grading system used in Vocational Agriculture.
7. Appreciate the value of FFA participation as a major part of the total Vocational Agriculture program.
8. Understand the total program concept of SOEP-Classroom Instruction-FFA.

OUTLINE OF UNIT

I. School Policies
   A. Student Handbook

II. Introduction to Vo-Ag (outline on board or prepare handout form Section I-G).
   A. 4 year curriculum and unit calendar (emphasis on first year of program)
   B. What to expect

III. SOEP Requirement
   A. Discuss Handout
   B. Take handout home to parents

IV. FFA
   A. Discuss Handout
   B. Discuss Calendar of Activities

V. Notebook Requirements
   A. Distribute Handout
   B. Discussion

VI. Grading
   A. Classwork grade
   B. SOEP grade

VII. Student Control Plan
   A. Handout
   B. State a few of your own rules and expectations
   C. Allow students to help you set rules and goals for the learning environment.

VIII. Total Program Concept-Summary
   A. FFA-SOEP-CLASSROOM
   B. Explain how each fits into the program

SUBJECT MATTER OUTLINE

I. School Policies
   A. Student Handbook
      1. Most administrations want teachers to go over the student handbook with students the first period of the first day of a new school year. If this is the case, comply.

II. Introduction to Vocational Agriculture
(Put 4-year unit calendar on the chalk board or prepare a handout to distribute to the students--ie. Section I-G of this curriculum guide).

NOTE: It should be noted that the Oregon curriculum guide is intended to be a guide only. Teachers should adjust the curriculum outline provided to assure coverage of technical agriculture skills and knowledge that is pertinent to the local area.

VOCATIONAL AGRICULTURE TEACHERS-
PLEASE ADJUST THIS CURRICULUM TO FIT YOUR LOCAL COMMUNITY NEEDS!!!!!!!

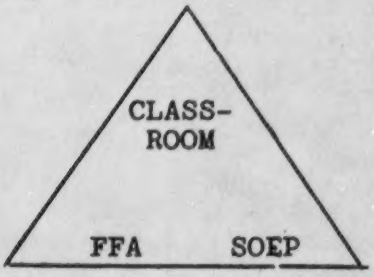
A. <u>What is Agriculture?</u>

To many people, agriculture is thought to be the production of plants and animals to provide the food and fiber for the people of the world. However, agriculture is more than that. Agriculture includes all occupations where knowledge, skills, and abilities are necessary for a person to enter into an agricultural occupation. Agriculture includes farmers, ranchers, buyers and sellers of agricultural products, agricultural mechanics, cowboys, inspectors, salesmen, chemists, teachers, scientists, economists and many other occupations. The total picture of agriculture includes the pure and applied science necessary to get the raw materials onto the supper table.

B. <u>What is Vocational Agriculture?</u>

Vocational Agriculture is an elective subject, offered students who want to work in some phase of agriculture. Vocational agriculture is designed to help prepare students to enter into an agricultural occupation and/or go on to further their education at a community college or at an agricultural college.

Vocational Agriculture has three main components to the program. Vocational agriculture can be pictured like this:



In order for our vocational agriculture classes to truly be successful we must have all three of the above stated components. Classroom instruction gives the students the knowledge and background information needed to begin working. SOEP gives the students the "hands-on" experience of actually applying the information presented in the classroom. This "hands-on" experience builds the skills necessary to gain employment. FFA allows opportunity to apply skills in a fun way. It also allows opportunity to gain recognition and develop leadership skills. FFA-SOEP-Classroom Instruction=Total Vocational Agriculture Program. These three parts form a triangle. With one part missing, the triangle falls apart. All students must be involved in the three parts for the program to be a success.

The first two years will be mainly exploratory in nature.

The last two years of vocational agriculture will be directed toward preparation for employment or entrepreneurship (owner-operator) in production agriculture or agri-business.

C. Explain the scope and sequence of the four year unit outline with emphasis on what students will learn and be able to do.

D. Concentrate attention on the first year of the program but describe how the total program fits together.

E. This is a motivational, student recruitment, and student selection effort. Treat it appropriately.

F. <u>How can a student get enrolled in Vocational Agriculture?</u>

1. Students should have an interest or a career goal in some phase of agriculture.

2. All students taking Vocational Agriculture will be required to have an occupational experience program in agriculture to make practical application of the class instruction. Supervised occupational experience programs can provide additional opportunity to develop responsibility, help establish goals, and set values and ideas for young people. The program will be periodically supervised by the Vocational Agriculture teacher. Examples of good SOEP'S are work experience in agriculture, livestock projects, crops projects and home improvement projects.

3. Each student will keep and maintain accurate records on their own supervised occupational experience program or project. This will teach good money management and decision making skills.

4. Each student will obtain a social security card.

5. All students are strongly urged to join and become a part of the FFA. The FFA will be used in the classroom to interest and involve students.

SUPERVISED OCCUPATIONAL EXPERIENCE PROGRAM
POLICY - VOCATIONAL AGRICULTURE DEPARTMENT

III.

A. INTRODUCTION

Due to the many first hand learning experiences each participant receives in planning, budgeting, feeding, managing, raising crops, construction, exhibiting, record keeping, etc., the supervised occupational experiences program (SOEP) is an essential part of the Vocational Agriculture Program.

B. POLICY STATEMENT

1. Each student enrolled in Vocational Agriculture will have an SOEP (Project).
2. The project should be tailored to fit each student's particular home situation, desires and occupational goals.
3. The student's project is used as a basis for many FFA awards.
   Through the FFA she/he can receive recognition by exhibiting livestock and crops at various shows, and also receive awards.
4. All students should have some home improvment project.
5. Production projects, cooperative work experience and supervised laboratory projects are also encouraged.
6. Periodically during the school year the instructor will check each student's project record book to evaluate his/her record keeping skills.
7. Evaluation will be on the following basis:
   1. Individual performance (progress)
   2. Record keeping skills
   3. Attitude towards the project.
   4. Applicability to students agricultural occupational goals
8. A long range plan will be completed by the student with the help of the vocational agriculture instructor and their parents. This plan will project a tentative plan of what the student will do to expand and refine the SOEP over the four years of enrollment in vocational agriculture.
9. Periodically during the school year and summer, the instructor will make project visits to the student's home or place of

employment to become familiar with each project, progress, planning and to provide assistance.

10. Satisfactorily meeting the above standards for supervised projects places a big responsibility upon each student in Vocational Agriculture. However, with a positive attitude, parental support, teacher and older student assistance, we seek each student's full cooperation in this important aspect of their Vocational Agriculture training.

11. The following pages contain a handout (SOEP Question & Answer Sheet) which students could have to take home to help explain SOEP to their parents.

SUPERVISED OCCUPATIONAL EXPERIENCE PROGRAM (SOEP)
QUESTION AND ANSWER SHEET

A. WHAT IS THE SUPERVISED OCCUPATIONAL EXPERIENCE PROGRAM?

The SOEP is an out of class project dealing with agriculture. It is a part of Vocational Agriculture curriculum across the United States.

B. WHAT IS THE PURPOSE OF THE SOEP?

The purpose of the SOEP is to provide actual training and career experiences in agriculture, for students.

C. WHO NEEDS TO HAVE AN SOEP?

Every Vocational Agriculture student must have an SOEP. It is a part of the agriculture class.

D. WHAT TYPES OF SOEP ARE THERE?

There are 5 types of SOEP available:

a. Agricultural Production projects (ie. crops & livestock projects)

b. Cooperative Work Experience (a job in production agriculture or agri-business)

c. Home Improvement (ie. Fence repair, Landscape improvement)

d. Supervised Laboratory Experience (ie. manager of school greenhouse or landlab)

e. Agricultural Services (ie. custom haying or combining)

E. WHAT ARE SOME SPECIFIC SOEP POSSIBILITIES?

There are many SOEP possibilities. Listed below are a few.

a. Raising a market animal: Beef, Sheep, Swine, etc.

b. Raising a breeding animal.

c. Planting a vegetable garden and selling the produce.

d. Growing a grain crop.

e. Working for a local farmer, nursery owner, etc.

F. BY WHAT DATE MUST THE SOEP BE STARTED?

All agriculture students must have a workable SOEP plan by January 10. Students will work on SOEP plans in class early in the school year. Normally the student will have actually started the SOEP by this date, however, some crops etc. project may not actually get underway until spring.

G. HOW WILL THE VOCATIONAL AGRICULTURE TEACHER SUPERVISE THE SOEP'S?

The vocational agriculture teacher will visit each student's SOEP during the school year for the purpose of supervision, assistance, and grading.

H. HOW WILL THE SOEP AFFECT VOCATIONAL AGRICULTURE CLASS GRADING?

The SOEP and related record book is worth approximately 10% of the total points possible. Any student without an SOEP (or acceptable plan) by January 10 cannot receive better than a "C" grade for the last two grading periods.

I. WHAT MAKES UP THE SOEP GRADE?

SOEP grading is based on two things:

a. The student's SOEP record book.

b. The instructor's visits.

Each student will be given a book in which to keep records on his/her project. A complete and neatly kept record book will receive maximum points.

On the SOEP visit the instructor will look for project management-whether the student is the primary person responsible for the SOEP, how well it is cared for, etc.

** NOTE: Projects should be of a type that relates to an agricultural occupational objective for the student. Students at the freshman and sophomore level may be refining agriculture course objectives and thus will be permitted some latitude in selecting their agricultural SOEP. With the instructor's assistance, the students will each determine at least tentative agricultural occupational objectives by the beginnning of the junior year. At a minimum, the student will indicate "production agriculture" or "agriculturally related business" at the beginning of junior year. The SOEP will

focus on gaining experience along the lines of this occupational objective.

IV. FFA

A. What about the FFA?

The Future Farmers of America, or FFA as it is commonly called, is an integral part of vocational agriculture. Through the activities of the FFA the in-class instruction can become more meaningful and useful to the students. Therefore, it is strongly urged that all students taking Vocational Agriculture join and participate in the various activities of the FFA.

The largest national student organization in America,made of, by , and for students in vocational agriculture... A chance for you to belong to a group of people who share and actively pursue their interests in the world of agriculture... An opportunity to increase the value of your vocational agriculture program at school by getting involved in agriculture outside of classroom...

That's FFA

THE FUTURE FARMERS OF AMERICA!!!!

*Activities in your FFA

--Field Trips to agricultural areas of interest.

Greenhouses, Feed Lots, Machinery Dealerships, Animal Hospitals. Where would you like to go?

--Contests that give you the chance to learn the best methods of feeding and caring for show animals or for raising crops to show at county fairs, state and even national championships. Compete with other FFA Chapters and states in public speaking, crop & livestock evaluation and mechanics.

--Leadership and self confidence are natural outgrowths of participation in FFA. Members learn to express themselves and organize their group using the same parliamentary procedure that our Congress uses. If leading your group sounds exciting there are lots of opportunities to polish your skills and even contests to compete in to show them off.

--Earn Money and Awards with your chapter or on your own. That S.O.E.P. steer you raise may earn FFA Awards as well as money. There are awards for team projects or for individual ones...Ribbons, pins, plaques, trophies, and purses are presented by the FFA to winning projects and to successful individuals.

--Travel with team members to districts, regional, state, and national contests and conventions. These are exciting opportunities to see new places and meet people. You can really go places in FFA.

--Community Service is a rewarding part of FFA. Find out how much you have to offer.

--Recreation is a big part of FFA. Picnics, Games, Hayrides, Dances....It's up to you what you decide to do. The list of recreations is only limited by your imagination.

What would you like to do?

It's to your advantage to be a part of today's FFA--

As a student, your future in agriculture depends on your experiences today. In the FFA you will be among people who have related goals and educational interests. The more exposure you have to agriculture today the better you will be able to find a satisfying place in the field of agriculture tomorrow. It's always more fun to become involved in your field in the company of others who share your interests. Get involved now. You'll always be glad you did!!

B. EXAMPLE FFA CHAPTER'S CALENDAR OF ACTIVITIES

SEPTEMBER

- Concession Stand
- FFA Meeting
- District Advisors Meeting
- County Fair
- Freshman Meeting
- FFA Creed Speaking Contest
- District Meeting
- State Officers Leadership Tour

OCTOBER

- Dues Deadline
- FFA Parent Potluck
- Concession Stand
- FFA Meeting
- P.I.L.E. Portland
- District Soils Judging Contest

NOVEMBER

- National FFA Convention - Kansas City, Missouri
- FFA Meeting
- Hay Ride
- District Advisors Meeting

DECEMBER

- FFA Meeting
- District Advisors Meeting
- Snow Party

JANUARY

- State Farmer Applications Deadline
- State Farmer Formal Interviews
- FFA Meeting
- District Advisors Meeting
- Chapter Public Speaking Contest

FEBRUARY

- Chapter Proficiency Award Contest
- FFA Meeting
- National Chapter Applications Deadline
- District Leadership Skills Contests
- National FFA Week
- District Proficiency Awards Contest
- Sectional Leadership Skills Contest

MARCH

- Chapter Officer Interviews
- District FFA Meeting
- District Officer Elections
- Chapter Book and Record Book Contest
- COOP Quiz Contest
- FFA Meeting
- State FFA Convention
- Slave Sale

APRIL

- FFA Meeting
- FFA Parent/Member Banquet
- Officer Installation
- Tractor Driving Test
- Shop Skills Contest

MAY

- FFA Meeting
- District FFA Meeting
- Livestock Judging
- Swimming Party
- Graduation

JUNE

- Livestock Shows
- FFA Meeting
- School's Out

JULY

- FFA Meeting

AUGUST

- County Fairs
- Livestock Judging Contests
- State Fair
- Leadership Camp
- State Tractor Driving Contest
- Ag Teachers Picnic

V. REQUIREMENTS FOR AGRICULTURE CLASS NOTEBOOKS

A. Each student will keep a class notebook which is comprehensive, current, and organized in the manner to be described below.

1. A good notebook serves several purposes:
   a. Record of student's performance in class.
   b. Reference source at some later date.
   c. Study materials for class tests.

B. ORGANIZATION

1. Each student will have their Agriculture notebook (looseleaf, 3 ring binder type) divided into four sections with each section divider marked in an easily noticable fashion.
   a. Each notebook shall have the following four sections in this order:
      1. Classroom Notes (in chronological order)
      2. Tests (with wrong answers corrected)
      3. Home work and other assignments
      4. SOEP Record Book

2. Each divider will be properly indexed and all materials will be kept in chronological order. Pages will be numbered and units will be listed on a table of contents immediately following each divider.

C. Evaluation of Notebooks

1. Notebooks will be evaluated once each quarter. The evaluation will be worth 100 points and will be based on completeness, organization, content and neatness.

2. A grade sheet will be placed in front of your notebook. This sheet will be used by the instructor for recording your notebook grade and comments on the notebook.

3. Deficiencies noted by the instructor should be corrected as quickly as possible. These items will be checked again the next grading period.

4. You are held responsible for the class notes on the days you are absent regardless of the excuse. It is your personal responsibility to see that any deficiencies caused by absences are made up.

5. You will need to bring a pen or pencil with you every day to class. Special note paper may be made available to you for class work.

VI. Grading

A. The grading system used in vocational agriculture will be a points system.

B. Each assignment will be given a specific number of points (ie. tests, homework, study guides, charts, SOEP records, lab activities and/or projects, notebooks, etc.)

C. At each nine week grading period the total number of points possible will be added. Grades will be determined on the basis of a percentage of the total possible.

90% +	= A
80-89%	= B
70-79%	= C
60-69%	= D
0-59%	= F

VII. DISCIPLINE AND MANAGEMENT SUGGESTIONS

A. Classroom control is a prerequisite to classroom learning and many times the key to control and discipline is good classroom organization and management. Achievement is greatly increased for students who are provided with learning experiences in a well disciplined and well organized atmosphere. Those who are not disciplined waste their own individual opportunities and make learning difficult for others. Positive discipline and classroom control and management can only result through joint effort upon the part of the teacher and student.

Organization

- Set classroom climate by how students enter and leave the classroom.
- Begin class promptly and with real enthusiasm. Use an attention getter or interest approach to motivate them.
- Have a routine in all classroom procedures to give security and establish precedents and policies.

Policies and standards

- Let student help set policies.
- Keep rules short and simple and adhere to them.
- Develop room standards of behavior.
- Carefully observe all rules expected of the class.
- Use lesson plans that will not be upset by restlessness at such times as before vacation.
- Make assignments clear.
- Be sure class members understand what they are to do. Check to see that directions are really clear.
- Hold every member of the class responsible for knowledge of each concept.
- Grade in terms of achievement of specified lesson/unit objectives.

Personal qualities

- Learn student's names quickly.
- Be friendly, smile and greet students by name.
- Develop a sense of humor which is the ability to have real fun and to laugh at

anything truly humorous.

- Let students know you are capable of laughing with them and at yourself.
- Use your voice to advantage by keeping it rich and calm and never speak over a noisy situation.
- Keep your voice audible but quiet, firm and low-pitched.
- Be impartial and fair. Do not play favorites or hold grudges.

Physical atmosphere

- See to it that ventilation and air circulation and lighting are good.
- Strive to keep the room pleasant and attractive.
- Use student activity, discussion and exhibits to create interest.
- Keep classroom orderly by sharing housekeeping responsibilities with students.
- Have supplies and equipment conveniently located.
- Have a place for everything and insist that items be kept in the proper place.

Classroom management

- Keep students busy by providing a full period of work.
- Be prepared; have alternate plans. Plan so students will have enough work all period, yet not frustrated by undue pressure.
- See that the class is busy before meeting the needs of the few.
- Know what each student is doing at all times.
- Divide large classes into smaller work and study groups.
- Avoid interruptions when students are working on a project.

Know your students

- Discover student interests and special activities.
- Spread responsibility and give each a chance to gain recognition in a positive way.
- Try to find the strong points of the behavior problem child. Help him to achieve.

- Gear teaching experiences to the interests and abilities of the students in class.
- Accept behavior for what it is and what it is trying to achieve. Try to fill the student's need another way so that a child will not have to use unacceptable behavior to gain his ends.
- Know your parents and the community.
- Study the seating of students carefully with an eye to possible necessary changes.
- Note acceptance of individuals by classmates.

Discipline ideas

- Be confident. Do not ignore small things. Be aware of them, and, if possible, correct offenders with quiet signals.
- Reprimand in private and not in front of the class.
- Try to handle your own classroom discipline before asking administrative assistance.
- Be consistent!
- Do not let discipline problems drag out. See what needs to be done and take the necessary action.
- Act after thinking through the consequences rather than threaten things that cannot be carried out.
- Be self-controlled.
- Do not argue! Discuss but do not overdiscuss.
- Do not create situations which encourage students to challenge your authority.
- Do not threaten and make "deals" to gain control.
- Listen to the student's side of any troublesome situation.
- Do not be afraid to stand your ground if behavior is not acceptable.
- Use common sense, have confidence in yourself and trust your judgement.

In Summary

Look at your own self in regard to:

- Self-confidence
- Voice

- Enthusiasm
- Sense of humor
- Personal appearance
- Fairness
- Optimism
- Promptness
- Manners
- Attitude
- Understanding
- Values

-Remember that behavior is caused, so work on the causes as well as the behavior.

-Work with parents and community and not by yourself.

-Do not expect change all at once as change takes time.

-Constantly re-evaluate your classroom techniques and look for new methods.

-Do your best! No one asks more!

Suggested example of a classroom control plan which could be a hand out for students follows (on the next page).

Caution: If you don't intend to comply completely and consistently with the suggestions on the handout - make up a handout of your own which you can enforce consistently. Share and agree on this plan with your administrator and with the students in your class.

THE CLASSROOM PLAN

GENERAL CONSIDERATIONS:

The most important mission of a teacher is to teach. Therefore, no student will be allowed to engage in activities during class that limit the educational process in any way.

To facilitate an optimum atmosphere for learning, the following classroom rules will be in effect:

1. Follow directions the first time.
2. No more than one speaker in the room at a time.
3. Be in your seat when the bell rings.
4. Ask permission to leave your seat.

Should these rules be broken at any time, the following steps will be implemented:

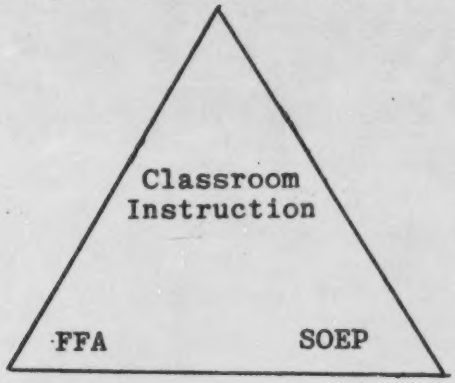
1. The offending student's name will be written on the chalkboard as a warning. It will remain there the rest of the period.
2. Should the student continue to break classroom rules, consecutive checkmarks will be placed behind the name.
   a) One check gives the student the choice of these three options:
      1) twenty pushups, done at the end of the class period
      2) a one-page report on an agricultural subject, due the next day
      3) ten minutes sitting quietly at a desk after school
   b) Two checks mean:
      1) forty pushups, or
      2) a two-page report, or
      3) twenty minutes after school
   c) Three checks mean:
      1) sixty pushups, or
      2) a three-page report, or
      3) thirty minutes after school
      4) an automatic phone call by the instructor to the student's parents
   d) Four checks earn an immediate trip to the Vice Principal, as well as one of the choices listed in step c above.
3. Any student who has not completed his/her assigned choice by the beginning of the next day's class will not be admitted to class until the choice is completed.

4. Any student causing a severe classroom disruption will be sent immediately to the Vice Principal.

VIII. Total Program Concept - Summary

A. Draw summary from students.

B. This vocational agriculture program has three parts (components)



In order to maximize the value of your election of vocational agriculture you should participate in the entire program not just the classroom instruction.

1. Classroom instruction accomplishes:
   a. Presentation of new information about agriculture in:
      a. Soil Science
      b. Animal Science
      c. Plant Science (Crops Horticulture)
      d. Agricultural Economics
      e. Agricultural Mechanics
      f. Leadership Development

2. SOEP accomplishes:
   a. On-site job experience.
   b. In-depth specialized technical agriculture learning.
   c. Specialization in one phase of agriculture.
   d. Development of working attitudes and habits.

3. FFA accomplished:
   a. Refinement and extention of classroom information.
   b. Travel and social experiences with agricultural industry.
   c. Development of verbal ability.
   d. Refinement of leadership skills.
   e. Community consciousness.

FARM FENCES

Instructor's Guide

1. This unit is based on two publications from AAVIM. Copyright restrictions will not allow materials to be presented with this unit.
2. The references needed for this unit are as follows:
   A. Planning Farm Fences - AAVIM Publication
   B. Building Farm Fences - AAVIM Publication
3. These two publications may be ordered from:

   Extension Business Office
   Extension Hall 118
   Oregon State University
   Corvallis, Oregon 97331
4. The objectives for this unit are keyed to chapters and pages of the references.
5. Planning of fences should be related to student's home farm, land laboratory or other lands within the student's range of familiarity.
6. Material from "Planning Farm Fences" can be presented in the classroom.
7. Material from "Building Farm Fences" should involve both classroom and laboratory excercises.
8. Practical applications in basic skills such as setting posts, bracing corners, stretching wire and gate construction are highly recommended for developing student competence in building fences.

Objectives

Upon completion of this unit, the student will be able to:

1. Plan a fence layout according to land use classification maps, topography, drainage, farmstead arrangement, cropping system, and ease of access to fields. ("Planning Farm Fences" 1: 3-10).
2. Determine the most appropriate kind of fence for the planned project. ("Planning Farm Fences" 2: 11-14).
3. Determine what quality of fencing materials to buy. Consider current costs, longevity of completed fence and effectiveness of fence in controlling livestock. ("Planning Farm Fences" 3: 15-24).
4. Determine the kind of end and corner construction to be used in the fencing project. ("Planning Farm Fences" 5: 29-36).
5. Determine the number and kind of line posts to be used in project. ("Planning Farm Fences" 6: 37-43).

6. Determine the types of passageways needed. ("Planning Farm Fences" 7: 44-50).
7. Lay out a fence line. ("Building Farm Fences" I: 5-10).
8. Clear a fence line. ("Building Farm Fences" I: 11-14).
9. Set wood fence posts. ("Building Farm Fences" II: 15-27).
10. Set and brace corner construction. ("Building Farm Fences" II: 15-27).
11. Set and brace steel posts. ("Building Farm Fences" II: 28-31).
12. Install barbed wire on posts. ("Building Farm Fences" II: 31-36).
13. Install woven wire on posts. ("Building Farm Fences" II: 37-46).
14. Ground wire fences for lightening protection. ("Building Farm Fences" II: 47-48).
15. Construct an electric fence. ("Building Farm Fences" III: 49-56).
16. Build gates. ("Building Farm Fences" IX: 89-96).

Student Activities

1. Plan a fencing layout for the home farm or school land laboratory.
2. Write a bill of materials for the planned fencing project. Plan should specify:
    a. Kind of fence to be constructed.
    b. Quality of fencing materials needed.
    c. Number of posts needed.
    d. Number of wire rolls.
    e. Bracing materials.
    f. Gate materials.
    g. Labor needed. (hours)
3. Complete a corner construction.
4. Set fence posts. (wood, steel)
5. Install woven wire.
6. Install barb wire.
7. Install electric fence wire.
8. Construct temporary gate.
9. Construct permanent gate.
10. Hang a gate.

Teaching Aids

1. Transparencies of planning and construction details selected from the reference books.
2. Common fencing tools.
3. Examples of fencing wires that show type, gage, barb numbers and spacing, coatings, etc.
4. Land capability maps.
5. Electric fence controller.
6. Posts, wire, brace materials, stretches and staples for demonstration of fence construction. Demonstration fence should include two fully completed corners and a short span of wire between them. Both barbed and woven wire installation can be demonstrated on the same set of corners.
7. Current prices of wire, posts, and brace materials from local sources.

REFERENCES: Planning Farm Fences - AAVIM. 1966.
Building Farm Fences - AAVIM. 1974.

SOILS

Instructor's Guide:

1. This unit is designed to provide basic instruction in soils for sophomore students.
2. Objectives for the total unit are compiled at the beginning of the unit to facilitate ease of duplication for student handouts.
3. Transparency masters are found at the end of each topic area. Certain transparency masters should be made into handouts for student use - - don't expect student to draw detailed drawings that you would have trouble drawing on the chalkboard yourself.
4. Instructors must adapt the material to their individual teaching styles and local resources.
5. The content of this unit was selected from curriculum materials developed by Texas A&M University.
6. The soil judging section was developed by Dr. Huddleston and Dr. Kling of the Soil Science Department at Oregon State University.
7. The materials that are available for teaching soils from Oregon State University are as follows:
   a. Manual for Judging Soils in Oregon
   b. Score Cards
   c. Score card Interpretation Card
   d. Rules for conducting soil judging contests in Oregon
   e. Slide set with manual- The Soils We Study (49 slides)
   f. Slide set with manual- Kinds of Soil (64 slides)
   g. How to take a Soil Sample OSU Extension Circular #628
8. All of the Oregon State University soils materials listed in number 7 above are available from:

   Extension Business Office
   Extension Hall 118
   Oregon State University
   Corvallis, Oregon 97331

   * Note: When ordering the slide sets a delay may be encountered because slide set processing is usually done in groups of ten or more.

   * Note: The "Manual for Judging Soils in Oregon" will be revised (including writing at a lower reading level) and the revision is planned for availability late in 1983 or early in 1934. Contact Herb Huddleston for up-dates.
9. All Oregon information is included in this instructional unit with the exception of the slide sets.

10. Upon completion of the revised "Manual" the Oregon materials could be used for the entire teaching unit. However, the current "Manuals" reading level is so high that it is suggested that you use the teaching material provided in this packet and use the current Oregon "Manual" primarily as a teacher reference. Supplement the teaching outline provided with "Manual" information and local examples.
11. Classes should have soil pits or road cuts available for "hands on" instruction in soils.
12. Student performance should be evaluated to determine if the objectives were met.

Objectives:

Upon completion of this unit, the student will be able to:

1. Define terms associated with soils.
2. Describe the process of soil formation.
3. Distinguish between physical and chemical weathering.
4. Label a drawing that shows the composition of an average soil.
5. Define soil texture.
6. List three soil particles that make soil texture and describe their relative size.
7. List five soil properties that describe soil differences.
8. Identify soil texture by "feel".
9. Identify the types of soil structure.
10. Determine soil texture by using the soil triangle.
11. Describe how soils are classified.
12. Label a drawing that shows the soil profile layers.
13. Collect a soil sample.
14. Prepare a soil sample for analysis.
15. Identify and state purpose of non-mineral elements in soil.
16. Identify the primary nutrients in soil.
17. List secondary nutrients in soil.
18. List six micronutrients in soil.
19. Describe the role of calcium, magnesium, and sulfur as essential plant nutrients.
20. Describe the role of iron, boron, manganese, copper, zinc, molybdenum, and chlorine as essential plant nutrients.
21. Define soil pH.
22. Describe effects of pH on plant growth.
23. Identify means for correcting soil pH.

24. Describe the effects of organic matter on the physical and chemical biological properties of soils.
25. Recognize soil nutrient deficiencies by looking at plants or pictures of plants with primary nutrient deficiencies.
26. Read label on fertilizer bag.
27. Distinguish between inorganic and organic fertilizers.
28. Identify common sources of N, P, K, in organic and inorganic forms.
29. Identify common methods of fertilizer application and appropriate use of each method.
30. Utilize a fertilizer recommendation sheet that is returned to producers from the Oregon State University Extension Service after a soil sample has been submitted.
31. Use the Oregon Soils Judging Score Card in evaluating soils.

Student Activities:

1. Read objectives.
2. Study information presented by instructor (the instructor has the option of Xeroxing the material in this unit or lecturing with appropriate discussion groups and laboratory excercises.
3. Complete field and lab excercises assigned by instructor.
4. Take unit exam.

Teaching Aids:

1. Objectives.
2. Information Units.
3. Transparency Masters Located at end of each topic.
4. Oregon State University Soil Judging Manual and Information Items.
5. It is strongly recommended that the Oregon State University slides be obtained and used for judging instruction.

Suggestion for Interest Approach:

1. Using the crop value data found in "Oregon's Leading Agricultural Commodities" and "Oregon Gross Farm Sales", discuss the

value of crops grown in the state and in your county. Discuss the importance of soil characteristics to the determination of which crops can be grown. Relate the type of crop grown to the value of the crop.

2. Option 2: Discuss the impact of soil management practices like burning field residue and tiling of fields to potential for crop production and types of crops which may be grown.

3. The Oregon Economic data needed is supplied following this discussion and may be obtained each January from:

Stan Miles
219 Extension Hall
Oregon State University
Corvallis, Oregon 97331

OREGON'S LEADING AGRICULTURAL COMMODITIES

Gross Farm Sales

1981

Rank	Commodity	1981p	1980r	1979
		thousand dollars		
1	Cattle & Calves	304,769	290,000	360,000
2.	Wheat	302,153	301,860	210,254
3.	Dairy	172,466	151,472	133,327
4.	Potatoes	96,999	83,489	63,830
5.	Nursery Crops	91,140	85,500	1/
6.	Alfalfa Hay	49,454	49,171	36,500
7.	Farm Forest	39,100	47,815	50,411
8.	Dry Onions	38,005	30,645	12,366
9.	Chicken Eggs	31,757	27,316	27,035
10.	Perennial Ryegrass	30,020	24,325	21,602
11.	Annual Ryegrass	27,438	23,485	19,291
12.	Barley	26,631	25,812	17,263
13.	Winter Pears	25,929	24,240	26,880
14.	Christmas Trees	25,563	20,610	15,574
15.	Broilers	24,661	23,342	23,251
16.	Peppermint	22,868	24,300	26,163
17.	Sweet Corn, Processed	22,079	17,902	20,216
18.	Sweet Cherries	20,777	15,900	20,672
19.	Snap Beans, Processed	20,647	24,714	26,380
20.	Sheep & Lambs	20,000	16,142	16,500
21.	Strawberries	19,918	15,333	14,370
22.	Hops	18,475	17,371	9,228
23.	Hogs	17,254	16,309	15,827
24.	Greenhouse Crops	17,115	14,899	1/
25.	Apples	15,532	14,820	18,700
26.	Filberts	13,920	17,380	12,078
27.	All Kentucky Bluegrass	11,170	11,642	10,214
28.	Turkeys	10,774	10,004	10,552
29.	Horses	10,166	7,447	6,918
30.	Sugarbeets for Sugar	8,800	9,176	4,550
31	Dry Field Beans	8,561	5,656	2,280
32.	Green Peas	8,478	9,363	7,595
33.	Oats	8,081	6,319	4,681
34.	Corn for Grain	8,072	2,436	2,114
35.	Bartlett Pears	7,373	13,600	14,620
36.	Hay (Other than alfalfa)	7,066	7,500	6,252
37.	Mink	6,669	5,958	5,620
38.	Bentgrass	6,498	6,854	8,550
39.	Sugarbeets for Seed	6,470	4,312	3,010
40.	Red Raspberries	5,791	2,979	6,820

p - Preliminary. r - Revised. 1/ not estimated separately.

Rank	Commodity	1981p	1980r	1979
		Thousand dollars		
41.	Red Clover	4,967	4,032	3,940
42.	Vegetables and Flower Seed	4,611	3,688	4,223
43.	Orchardgrass	4,556	6,792	6,120
44.	Chewings Fescue	4,489	7,075	5,184
45.	Tame Blackberries	4,419	5,875	8,162
46.	Turf Sod	4,340	5,215	1/
47.	Corn Silage	4,153	4,527	3,943
48.	Red Fescue	3,846	4,200	3,848
49.	Cranberries	3,553	2,722	2,523
50.	Prunes & Plums	3,527	4,983	4,784
51.	Peaches	3,480	2,899	3,072
52.	Bulbs	3,425	3,195	2,893
53.	Alfalfa Seed	3,366	5,415	5,166
54.	Cucumbers, Processed	2,907	2,712	2,374
55.	Crimson Clover	2,846	1,433	2,300
56.	Grapes	2,835	2,091	1,734
57.	Wool	2,797	3,220	3,210
58.	Squash & Pumpkins	2,584	2,029	1,800
59.	Blueberries	2,538	1,400	1,572
60.	Tall Fescue	2,518	2,618	1,872
61.	Cauliflower, Processed	2,480	2,895	2,381
62.	Dry Field Peas	2,469	2,628	2,673
63.	Cabbage	2,421	2,094	1,620
64.	Turkey Eggs	2,346	2,459	2,154
65.	Sweet Corn, Fresh	2,216	2,225	2,138
66.	Beets, Processed	2,011	1,927	2,067
67.	Lettuce	1,958	1,862	1,667
68.	Cauliflower, Fresh	1,811	1,500	1,254
69.	Carrots, Fresh	1,680	2,086	910
70.	Tart Cherries	1,639	1,015	1,519
71.	Broccoli, Processed	1,634	1,437	1,200
72.	Watermelon	1,570	1,280	885
73.	Spearmint for Oil	1,535	1,470	1,453
74.	Austrian Peas	1,348	1,254	1,613
75.	Honey & Beeswax	1,305	1,264	1,196
76.	Hairy Vetch	1,263	868	1,900
77.	Garlic	1,242	1,288	1,069
78.	Tomatoes	1,235	925	969
79.	Walnuts	1,225	1,425	1,444
80.	Boysenberries	1,185	1,064	1,873
81.	Pinto Beans	1,126	1,650	n/a
82.	Asparagus	1,119	582	527
83.	White Clover & Ladino	1,085	1,037	772
84.	Carrots, Processed	1,038	925	1,086
85.	Rabbits	1,027	1,011	716
Other commodities		39,602	41,738	117,590 2/
TOTAL GROSS FARM SALES		1,759,966	1,663,428	1,512,830

p - Preliminary. r - Revised.

1/ not estimated separately.

2/ includes nursery crops, greenhouse crops and turf sod.

SOURCE: Compiled by Extension Economic Information Office, Oregon State University.

OREGON GROSS FARM SALES
Preliminary 1981 Estimates

District & county	Grains	Hay & silage	Grass & legume seeds	Field crops	Tree fruits & nuts	Small fruits & berries	All vegetable crops	Specialty products	All crops	Cattle & calves	Dairy products	Eggs & poultry	Misc. animals	All livestock & products	Total gross income
	thousand dollars														
The State....	345,203	61,941	106,797	173,105	96,462	38,903	123,574	202,403	1,148,388	304,769	172,466	67,695	66,648	611,578	1,759,966
District 1...	62,556	8,127	91,323	41,976	30,012	33,127	85,067	162,368	515,156	34,775	78,505	60,245	31,453	204,978	720,134
Benton.....	4,495	468	7,005	2,494	759	725	4,621	7,325	27,892	1,890	3,780	209	1,337	7,216	35,108
Clackamas..	4,945	796	3,144	1,042	2,681	5,193	10,794	37,880	66,475	4,935	6,950	20,602	8,633	41,120	107,595
Lane.....	4,156	353	4,922	4,159	3,128	821	6,621	11,250	35,410	6,518	7,440	7,368	1,886	23,212	58,622
Linn.....	7,615	1,066	45,785	5,517	832	1,477	5,202	5,644	73,138	5,682	8,813	4,835	6,932	26,262	99,400
Marion.....	10,944	1,569	16,123	23,574	5,446	10,526	37,144	40,020	145,346	5,854	23,487	10,165	4,735	44,240	189,586
Multnomah..	556	81	98	352	144	3,523	6,347	21,297	32,398	745	1,623	10	561	2,939	35,337
Polk.....	10,787	723	5,309	3,123	3,835	863	1,712	5,545	31,897	2,497	5,167	4,537	1,655	13,856	45,753
Washington.	7,227	1,966	5,019	1,271	6,067	9,945	7,514	24,945	63,054	3,042	12,065	580	2,069	17,756	80,810
Yamhill....	11,831	1,105	3,918	444	7,120	954	5,112	9,062	39,546	3,612	9,180	11,939	3,646	28,377	67,923
District 2...	537	436	40	60	39	5,041	171	13,692	20,016	16,912	54,968	293	6,152	78,325	98,341
Clatsop....	---	66	---	---	---	58	5	1,900	2,029	1,193	2,046	8	1,874	5,121	7,150
Columbia...	537	132	40	38	21	1,320	76	3,700	5,864	3,037	2,984	8	450	6,479	12,343
Coos.....	---	99	---	---	13	3,220	10	2,677	6,019	4,873	11,583	249	1,438	18,143	24,162
Curry.....	---	18	---	---	5	341	---	2,390	2,754	1,546	891	5	1,012	3,454	6,208
Lincoln....	---	27	---	---	---	53	50	1,725	1,855	1,097	314	23	359	1,793	3,648
Tillamook..	---	94	---	22	---	49	30	1,300	1,495	5,166	37,150	---	1,019	43,335	44,830
District 3...	2,428	1,549	572	1,402	16,357	452	1,889	14,338	38,987	21,492	14,892	4,187	7,465	48,036	87,023
Douglas....	1,435	494	153	36	2,411	425	1,416	8,250	14,620	10,679	1,286	647	5,071	17,683	32,303
Jackson....	941	762	419	198	13,706	27	377	3,154	19,584	8,485	5,945	3,404	1,713	19,547	39,131
Josephine..	52	293	===	1,168	240	---	96	2,934	4,783	2,328	7,661	136	681	10,806	15,589
District 4...	219,732	13,618	1,142	60,293	48,301	267	13,036	5,710	362,099	48,449	1,691	2,168	8,861	61,169	423,268
Gilliam....	22,804	269	234	173	---	---	---	10	23,490	4,327	---	---	195	4,522	28,012
Hood River	---	135	-	---	31,484	99	95	770	32,573	732	507	364	449	2,052	34,625
Morrow.....	49,476	6,830	---	36,900	99	---	137	1,550	94,992	6,923	436		1,422	10,781	105,773
Sherman....	32,306	54	---	40	15	---	---	---	32,415	1,813	---	1,795	127	3,735	36,150
Umatilla...	91,238	5,570	908	23,056	5,857	168	12,712	2,830	142,334	23,432	748	6	5,314	29,500	171,839
Wasco.....	23,404	698	---	---	10,846	---	102	400	35,450	5,740	---	3	1,051	6,794	42,244
Wheeler....	504	62	---	124	---	---	---	150	840	3,482	---	---	303	3,785	4,625
District 5...	38,957	7,107	7,676	34,445	1,474	16	22,994	2,030	114,699	84,682	15,074	24	4,679	104,459	219,158
Baker.....	3,553	1,202	43	170	20	---	---	360	5,348	18,051	2,422	3	832	21,308	26,656
Malheur....	16,268	4,012	2,202	32,503	243	16	22,967	100	78,311	51,262	11,887	10	1,493	64,652	142,963
Union.....	13,420	793	5,431	692	1,211	---	---	870	22,417	5,111	610	8	1,442	7,171	29,588
Wallowa....	5,716	1,100	---	1,080	---	---	27	700	8,623	10,258	155	3	912	11,328	19,951
District 6...	20,993	31,104	6,044	34,929	279	---	417	3,665	97,431	98,459	7,336	778	8,038	114,611	212,042
Crook.....	1,376	6,615	150	2,859	---	---	8	250	11,258	12,688	575	31	492	13,786	25,044
Deschutes..	619	1,901	113	1,253	---	---	---	950	4,836	4,215	2,371	20	1,716	8,322	13,158
Grant.....	433	882	---	374	279	---	---	1,260	3,228	9,709	---	40	1,808	11,557	14,785
Harney.....	1,110	2,848	36	132	---	---	---	10	4,136	19,207	---	---	501	19,708	23,844
Jefferson..	7,296	1,785	5,697	12,074	---	---	409	175	27,436	9,443	---	3	1,227	10,673	38,109
Klamath....	8,412	10,088	20	17,885	---	---	---	900	37,305	26,527	4,315	684	1,693	33,219	70,524
Lake.....	1,747	6,985	28	352	---	---	---	120	9,232	16,670	75	---	601	17,346	26,578

SOURCE: Compiled by Extension Economic Information Office, Oregon State University.

December 1981

HARVESTED ACREAGE SUMMARY*

Oregon Counties, 1981

Counties	Grains	Hay & forage	Grass & leg seeds	Field crops	Tree Fr & nuts	Sm Fru & ber	All Veg crops	Spec. Products	Total
State Total	1,613,000	1,118,550	339,340	155,790	79,589	15,549	125,320	2,432	3,450,512
District 1	327,800	175,100	302,030	36,170	40,803	13,888	84,954	2,032	983,702
Benton	22,400	11,900	23,600	2,850	628	225	6,806	540	68,955
Clackamas	33,300	26,200	11,100	590	3,720	2,705	5,710	520	83,845
Lane	24,300	23,300	16,660	5,730	3,800	335	9,142	100	83,365
Linn	40,800	26,400	148,950	7,665	855	550	6,940	122	232,292
Marion	54,900	22,300	45,050	15,230	6,500	4,725	41,444	270	190,415
Multnomah	3,900	3,300	400	250	140	1,300	2,475	10	11,780
Polk	54,600	14,700	21,240	2,390	5,580	433	2,795	340	102,085
Washington	35,100	25,000	18,000	1,085	10,020	3,100	3,432	100	96,740
Yamhill	58,500	22,000	17,030	380	9,560	515	6,210	30	114,225
District 2	3,550	37,300	245	90	32	1,363	120	70	42,770
Clatsop	---	4,000	25	---	---	---	---	---	4,025
Columbia	3,550	8,800	220	70	32	480	120	50	13,320
Coos	---	12,500	---	---	---	748	---	10	13,260
Curry	---	2,500	---	---	---	91	---	---	2,590
Lincoln	---	3,000	---	---	---	30	---	10	3,040
Tillamook	---	6,500	---	20	---	14	---	---	6,535
District 3	15,650	84,100	750	1,265	12,906	168	1,060	150	116,060
Douglas	10,400	47,300	270	55	2,100	155	805	90	61,185
Jackson	4,900	27,600	480	260	10,635	13	213	40	44,145
Josephine	350	9,200	---	950	171	---	42	20	10,730
District 4	952,100	124,100	2,510	45,860	24,704	125	27,826	150	1,177,375
Gilliam	139,500	7,600	480	430	---	---	---	---	148,010
Hood River	---	2,150	---	---	15,210	45	26	---	17,435
Morrow	224,750	30,700	---	27,350	40	---	80	150	283,070
Sherman	151,750	950	---	250	12	---	---	---	152,960
Umatilla	335,800	57,700	2,030	17,730	3,605	80	27,697	---	444,650
Wasco	96,600	13,000	---	---	5,837	---	23	---	115,460
Wheeler	3,700	12,000	---	100	---	---	---	---	15,800
District 5	187,300	231,100	16,285	42,100	1,010	5	11,080	---	488,885
Baker	21,300	72,600	150	330	20	---	---	---	94,400
Malheur	59,500	97,500	5,250	38,870	140	5	11,020	---	212,285
Union	69,000	31,000	10,885	2,500	850	---	---	---	114,240
Wallowa	37,500	30,000	---	400	---	---	60	---	67,960
District 6	126,600	466,850	17,520	30,305	134	---	280	30	641,720
Crook	4,900	49,000	550	2,920	---	---	---	---	57,370
Deschutes	3,650	22,700	370	1,050	---	---	---	---	27,770
Grant	2,850	46,000	---	630	134	---	---	---	49,610
Harney	16,600	131,000	1,500	120	---	---	---	---	149,220
Jefferson	30,350	17,150	15,020	15,955	---	---	280	30	78,790
Klamath	43,150	71,000	---	9,000	---	---	---	---	123,150
Lake	25,100	130,000	80	630	---	---	---	---	155,810

*Acreage estimates are not included for many specialty crops, pastures and rangeland areas.

SOURCE: Compiled by Extension Economic Information Office, Oregon State University. December 1981

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Terms and Definitions

1. Soil -- The mineral and organic material that supports plant growth on the earth's surface.
2. Soil profile -- The cross section of a soil from the top to the bottom.
3. Soil texture -- The size of the individual soil particles such as sand, silt, and clay.
4. Soil color -- An indication of the amout of organic matter, moisture, and texture of the soil.
5. Soil structure -- The way the individual soil particles are grouped together to form clusters of particles.
6. Rock weathering -- The process by which rocks are broken down into soil-sized particles through exposure to the weather and various living organisms over hundreds of years.
7. Leaching -- The removal of soil components from the soil by the downward action of water.
8. Rock -- A more or less consolidated mass composed of two or more minerals.
9. Aggregate -- A single mass or cluster of soil particles such as a clod, crumb, or granule.
10. Slope -- The number of feet or rise in each 100 feet of run (longitudial distance of 100 feet).
11. Permeability -- The movement of air and water through the soil.
12. Depth -- The total thickness of soil from the topsoil to the parent material.
13. Horizon -- One layer of a soil profile.
14. Soil series -- A classification of soils.
15. Primary nutrients -- Nitrogen, Phosphorus, and Potassium.
16. Secondary Nutrients -- Calcium, Magnesium, and sulfur.
17. Micronutrients -- Minerals needed in small quantities by plants.
18. Organic matter -- Decaying plant and animal residue.
19. Soil deficiency -- Shortage of a nutrient that harms plant growth.
20. Soil Judging -- Determining the characteristics of a given soil for crop production, forest production, housing or other uses.

Soil Science

Topic 1: Soil Components

*All terms underlined are included in the "Glossary of Terms."

I. Soil Origin

It is the custom of agronomists to refer to the origin of the parent material of soils (a factor influencing soil formation) when referring to the nature of the soil. It is desirable to have an understanding of the origin and classification of parent material before considering the origin and classification of soils.

Soil parent materials may be referred to as a geological formation. It is a layer of material varying from a few feet in thickness to many feet. Wherever a geological formation is exposed at the earth's surface, either there is soil formation taking place or a soil has already developed from the exposed material. Productive soils develop only from minerals and rocks which are plentifully supplied with all essential elements needed to support plant life.

Transparency No. 1

Parent materials from which soils are formed may be classified as residual, transported or cumulose.

A. Residual Materials

Residual materials are those which have developed from the underlying rocks and minerals. Most rock formations at the earth's surface are sedimentary. Other rock formations are classified as igneous or metamorphic.

Examples of residual materials are those which have weathered from limestone, sandstones, shales and slates, and many crystalline rocks such as granites and basalts.

B. Transported Materials

1. Materials that have been transported by water are classified as alluvial, lacustrine, or marine.
   a. Alluvial materials are sediments which have been transported by flowing water, such as small streams or large rivers.
   b. Lacustrine materials are those which have eroded into lakes from surrounding uplands. These materials were deposited in fresh-water lakes during glacial times. The greatest lacustrine deposits in the United States are bordering the Great Lakes. In Oregon Lake Labish in the Salem area is a prime example.

c. Marine materials are those which were formed as sediments and were washed out to sea by rivers and later lifted above sea level. The principal marine sediments occur along the Gulf Coast and the Atlantic Coast.

2. Materials transported by wind are classified as either eolian deposits or loess deposits.
   a. Eolian deposits are sand dunes or deposits from present day dust storms.
   b. Loess deposits are soil materials that were deposited following the last glacial period. Loessial soil materials are silt-loam in texture and are found mostly in the Mississippi Valley.

3. Materials transported by ice are commonly classified into three topography types namely, moraines, till plains, and outwash plains. The best known example of a glacial moraine in Oregon is the east bank of Wallowa Lake. Ice deposits, according to geologists, were formed four times during our geologic history. The climate became so cold that a huge sheet of ice, one mile thick in places, moved south from Canada and covered the United States. As the ice moved southward, it ground the rocks beneath, gouged the valleys, scoured the loose materials off the hills, and mixed them together. This mixture, called glacial till, contained fine particles, stones, and sometimes huge boulders. This process of soil formation took place over a period of hundreds of years. Unlike residual soils, the glacial till does not contain underlying rocks.

4. Materials transported by gravity exist to some extent at the base of all slopes. The soil materials that moved to the base of the slope in response to gravity is called colluvial material. It is more noticeable in mountainous topography where rock slides, slips, and avalanches are common.

C. Cumulose Material (Organic) - peat and muck

Cumulose materials are the plant residues that have been developed in shallow lakes, or at the mouth of coastal streams, and are recognized as peat and muck. Peat is the term used for material when the plants are recognizable. Muck describes the material when plants have decayed beyond recognition. The Coos Bay and Astoria areas along the Oregon Coast have peat bogs which are intensively cropped.

Parent materials are the plant residues that have been developed today as rocks and minerals are weathered by both physical and chemical processes. Physical weathering processes include constant temperature changes, climatic conditions, rainfall, erosion, the action of animals, plants, and man. Chemical processes include such factors as oxidation, reduction, solution, hydrolysis, hydration, and carbonation.

II. The General Components of Soils

A. It should be emphasized at this point that soils develop from parent material by processes of soil formation that differ from processes of rock weathering, which produce parent material. As a soil is developed from the parent material certain changes take place which distinguish the various soil layers and soil components. These changes are brought about largely by the shifting of materials or components either mechanically or in solution within the various soil layers.

Transparency No. 2

B. Soils are made of living and non-living materials which are of three forms; solids, liquids, and gases. The organic matter and minerals in the soil are the solid materials; and the air and water, which move through the soil pores, are the gases and liquids. Approximately 45 to 49% of the soil (by volume) is mineral, 1 to 5 percent is organic matter, and 50% is water and air.

1. The mineral in the soil is inorganic and contains approximately sixty-four elements, which could be available to the growing plants. Some of the elements are of minor importance, but fourteen are considered to be of prime importance. Some of the important elements are nitrogen, phosphorus, potassium, carbon, oxygen, sulfur, calcium, iron and chlorine. The mineral elements in the soil, with the exception of those introduced by man, come from rocks and decayed plants and animals.
2. Organic matter, another of the earth's solids, is formed from decomposed plants and animals such as plant roots, crop residue, green manure crops, and stable manure. Soils high in organic matter also are high in soil microorganisms, which affect the rate of decomposition of plants. Microorganisms obtain their energy, as do animals, by oxidizing organic matter. The amount of organic matter, often called humus, in the soil to some extent depends on climate and drainage and the management pratices of land owners. Activities such as field burning reduces soil organic matter.

The physical features, called tilth, of the soil are affected by the amount of organic matter in the soil. A high organic matter content in the soil will give the following benefits:

a. Makes the soil porous
b. Supplies nitrogen to the growing plant
c. It helps hold water in the soil so that growing plants are protected against droughts.
d. It aids in managing the soil moisture content.
e. Furnishes food for soil organisms.

f. Serves as a store house for soil organisms.
g. Minimizes leaching.
h. Serves as a source of nitrogen and growth promoting substances.
i. Stablizes the soil structure.

Soil water and air, the liquids and gases in the soil, are necessary for plant growth. The soil absorbs a great amount of water during rains, and water that is not absorbed by the soil drains away unless measures are taken to conserve it. The amount of moisture and air in the soil varies depending on climatic conditions. As the soil absorbs more water, there is less air in the soil; and as the soil absorbs more water, there is less air in the soil; and as the soil dries out, air replaces the moisture. Plants receiving excessive water for too long a period of time will die because of a lack of oxygen. Soil in good physical condition will hold more water and air than poorer conditioned soils. A crop like ryegrass can withstand (is tolerant to) more water in the soil over long periods of time than a crop like strawberries. Therefore, much of the poorly drained soils in the Willamette Valley are producing grass seed crops.

III. The Size of Soil Particles

A. A mechanical analysis is used to determine the percentages of different size groups of soil particles. These groups of soil particles (or soil seperates) are determined by diameter ranges and are classed from coarse to fine.

Transparency No. 3

B. The size of soil particles is important because it affects the water holding capacity and workability of the soil. Gravel, sand , silt, and clay are the four mineral particles found in the soil.

1. Gravel and sand, the larger particles, can be seen with the eye; soils with a high percent of gravel and sand are infertile because they do not provide nutrients to the growing plants. These soils dry out quickly and are drouthy.
2. Silt particles are between those of sand and clay in size, and until they have weathered to fine-sized particles, they provide few nutrients for the growing plant. After rains, soils with a percent of silt tend to run together and form a soil crust, and they erode very easily.
3. Clay, the smallest of the soil particles, holds soil nutrients, determines the acidity of the soil, and holds more moisture than either sand or silt. Clay particles are microscopic in size; their expansion and contraction depend on the amount of moisture present. In the presence of water, clay particles are seperated by a film of moisture; as the moisture evaporates and the soil becomes dry, the soil contracts and leaves a crack in the ground. Clay soils dry out slowly and become cloddy unless properly managed. A good mixture of soil should contain sand, silt, and clay.

classification of PARENT materials

A. RESIDUAL MATERIALS

1. Sedimentary -limestone, sandstone, shale
2. Igneous- granite, basalt, andesite
3. Metamorphic- marble, quartzite, gneiss

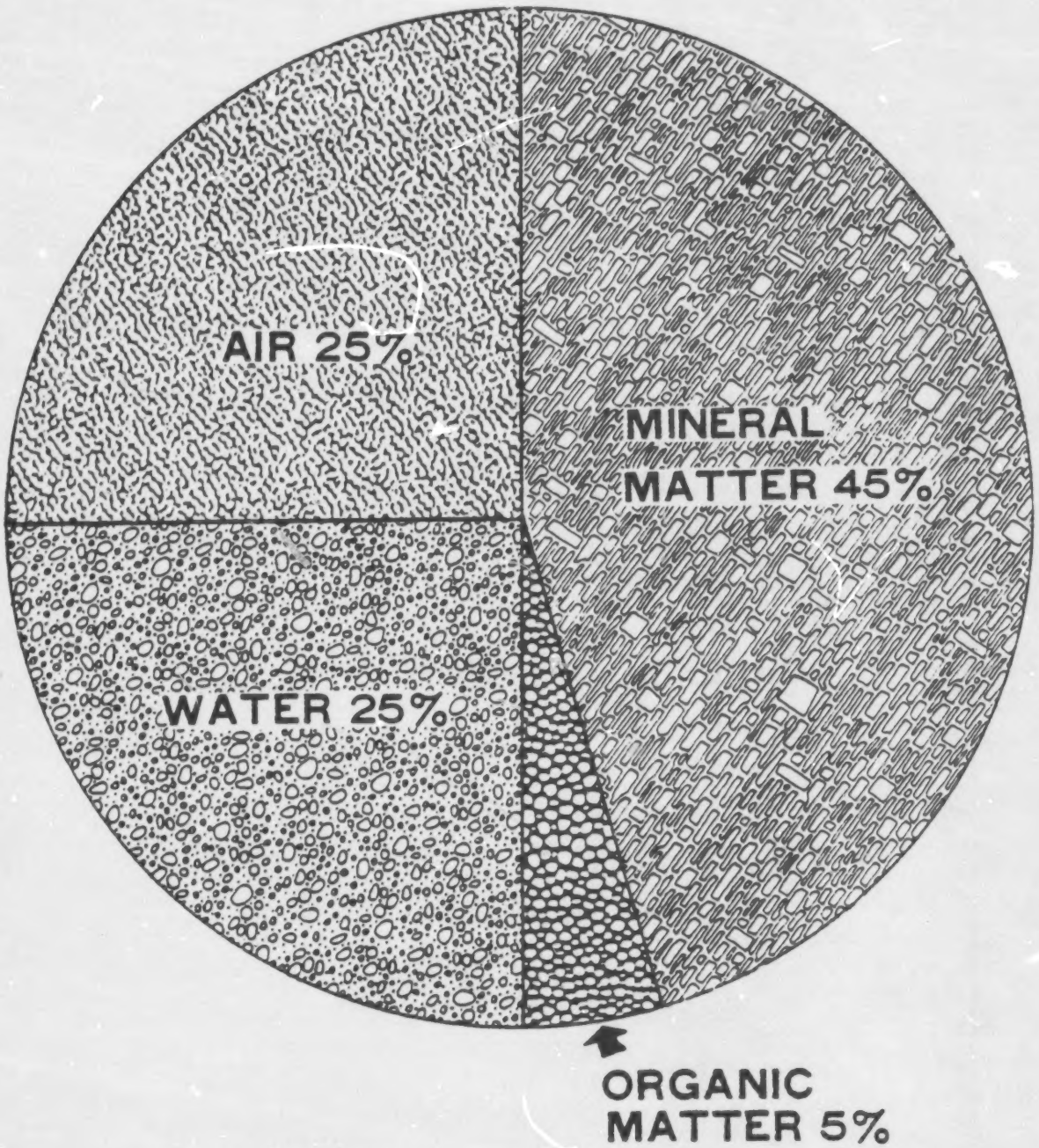
B. TRANSPORTED MATERIALS

1. Water
   - A. Alluvial -flowing water
   - B. Lacustrine -lakes
   - C. Marine- ocean
2. Wind
   - A. Eolian- sand dunes
   - B. Loess-silt loam deposits (Miss. Valley)
3. Ice
   - A. Moraines
   - B. Till Plains
   - C. Outwash plains
4. Gravity- colluvial

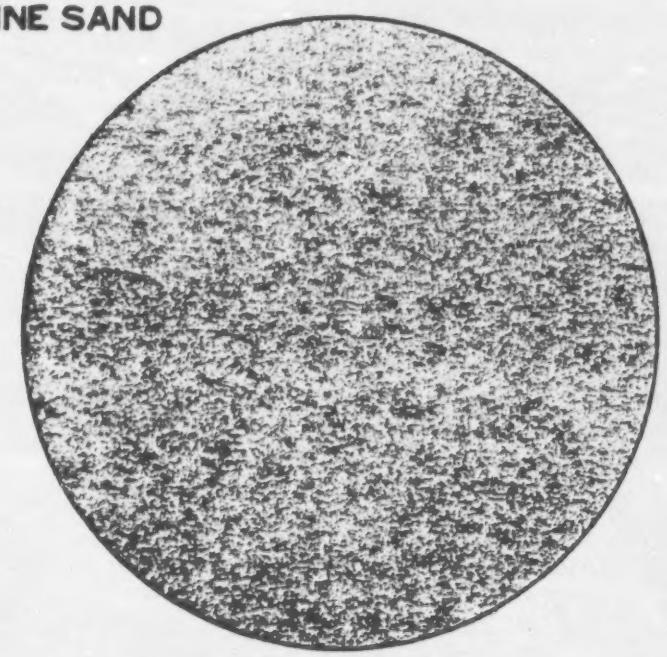
C. CUMULOSE MATERIALS

1. Peat- recognizable plant material deposits
2. Muck- plant decay deposits beyond recognition

COMPOSITION of AVERAGE SOIL



THE RELATIVE SIZES OF SAND, SILT, AND CLAY PARTICLES



SIZE OF SOIL PARTICLES

NAME	SIZE, DIAMETER IN MILLIMETERS
FINE GRAVEL	2 - 1
COARSE SAND	1.00 - 0.50
MEDIUM SAND	0.50 - 0.25
FINE SAND	0.25 - 0.10
VERY FINE SAND	0.10 - 0.05
SILT	0.05 - 0.002
CLAY	LESS THAN 0.002

Soil Science

Topic 2: Soil Properties

*All terms underlined are included in the "Glossary of Terms."

1. Major Factors Used to Describe Soil Differences

Although soils in general are made up of the same components, they differ in their properties or characteristics; and these differences affect or determine the way in which they should be managed. Soils differ in their color, texture, structure, consistence, and fertility and productivity. Even though many years of proper soil management are required to change the characteristics of the soil, farmers can make considerable improvements in the structure, fertility, and productivity of the soil.

A. Soil Color

Color is one of the most easliy recognized soil characteristics and is very apparent in a soil profile. The surface colors of soil are classified as dark, moderately dark, light or very light; and the subsoil colors are classified as dull, mottled, or bright. The surface soil has a much darker color than subsoils because it usually contains more organic matter.

The color of the soil is usually a good indication of the amount of organic matter, the amount of moisture, and the texture of the soil. The dark color of topsoil usually indicates presence of organic matter. Light-colored soils are generally low in organic matter content, or high in sand particles, or contain iron or manganese oxide.

Soil drainage, which is the movement of water through and off the soil, affects the color of the soil and will determine the kinds of crops that can be planted. The color of a well-drained soil is red or brown; fair-drained soils are yellow or light brown , and poorly-drained soils are gray. A mottled subsoil indicates that the soil is saturated with water at certain times of the year and dry at other times. In order to standardize color determination, color of soil is always interpreted when the soil is wet.

B. Soil Texture

Soil texture refers to the size of the individual soil particles, and is thought of as the fineness or coarseness of soil particles, determined by the percent of sand, silt, and clay in the surface layer of the soil. Most soils contain a mixture of sand, silt, and clay; it would be unusual to find a soil made up of only one of these. Soil textural classes denote the average or combined effect of the soil particle sizes in a given sample. In the laboratory, soil texture is determined by a mechanical process of seperating the soil into groups of grain sizes.

Transparency No. 1

Each of the soil particles has a distinctive feel; with a knowledge of soil textural classes and some experience, students should be able to determine the texture of the soil. The student should work some moist soil in their hand. Sand particles will feel gritty and coarse and will mold; however, the molded sand may fall apart when the hand is opened. Silt particles are sticky and gummy in moist soils and floury in dry soils. As moist silt particles are worked between the thumb and index finger, they will stick together and fall off the finger in large pieces. Clay particles are very sticky. When worked between the thumb and index finger, clay will form a leaf of soil up to one inch in length before it falls off the finger.

For convenience in determining the textural name of a soil from the mechanical analysis, an equilateral triangle has been adapted.

Transparency No. 2

The textural triangle gives the percent of sand, silt, and clay in each of the textural classes.

B. Because of their large size, sand and large silt particles have a low-specific surface, or low surface area per unit mass. Since most of the important chemical and physical-chemical reactions in soils take place at the particle surface, the amount of surface area affects the ability of soils to react to chemicals. Soils with a high percentage of large particles lack plasticity and cannot retain large amounts of water or nutrients. However, the organic matter content of these soils can be increased, thus increasing the amount of nutrients and moisture available to plants.

C. Soil Structure

Soil structure, the arrangement of soil particles into various sizes and shapes, is important because it affects the soil tilth and management decisions made by the farmer. The particles in different type soils stick together differently and give the soil particles a different shape. The farmer can control the soil structure through their method of cultivation, time of cultivation, and by regulating the amount of organic matter. Good farmers try to keep their soils in a good state of tilth at all times.

Soils with a good structure contain a lot of crumbs or aggregates, which indicate good tilth. Good structured soil permits deeper root penetration and a greater area from which the plant can secure nutrients.

An example of two different types of soil structure could be obtained by taking a soil sample from an area with a dense, heavy growth of grass and taking a sample from a field that has been in continuous cultivation. The sample taken from the grassy area will be grainy and will contain a large amount of aggregates, while the sample taken from the field will be firm, hard, and will lack aggregates or crumbs.

Transparency No. 3

Soil scientists classify structural aggregates of soils into three main categories, based upon their shape, size, and strength.

The main soil structure types determined by the shape and arrangement of aggregates are granular, prismatic, blocky, and platy. Evidence of the soil structure types can usually be observed when a clod of soil is broken. If the cracks or lines of cleavage are mostly vertical, the soil has a prismatic or columnar structure; when cleavage is mostly horizontal, a platy structure exists; and when the cracks or cleavage are about equal, the soil has a blocky or granular structure.

Class of soil structure is determined by the strength of the soil aggregates and they are commonly classed as coarse, medium, or fine. Size of soil aggregates varies with their shapes.

Grade of soil structure is determined by the strength of soil aggregates. Strength of the soil aggregate is measured by its resistance to crushing. Soils are considered to be structureless when the particles of coarse soil fail to cling together, or when fine soil breaks into large cementlike clods. Other descriptive grades of soil structure are weak, friable, and firm.

Transparency No. 4

In order to describe soil structure, scientists have named the shape of each kind of structure in which the particles arrange themselves differently. The six most common types of soil structure are single grain, granular, blocky, prismatic, platy, and massive.

Soil structure influences many important functions of the soil, such as the infiltration rate of water. Soils with a single grain or granular structure possess a rapid rate; soils with a blocky or prismatic structure have a moderate rate; and soils with a platy or massive structure have a slow rate of infiltration.

Since soil structure is important to soil management, the farmer or student should become familiar with the maintenance of good structure and the formation of aggregates or crumbs. Soil particles are grouped into aggregates by the action of complex sugars. While one part of the sugar arranges the soil particles loosely into clusters, another part is binding the particles firmly into aggregates. Before soil particles can be bound into aggregates, they must be grouped into loose clusters.

Flocculation, the first step in forming a soil aggregate, is caused by nature. Flocculation pulls the clay particles close together so that they are cemented with gum, which is made from soil sugars. The second step in aggregate formation is the binding of the clay particles in the flocs into aggregates.

The removal of plant cover from soil destroys aggregation and the sugars that bind the particles. The longer the soil is without a cover, the more breakdown there is in the aggregate. As plants cover the soil, aggregates start to build and the breakdown stops.

D. Soil Consistence

Consistence refers to the cohesiveness of soil or its resistance to rupture or deformation. Soil consistence and structure are interrelated in that structure deals with the shape, size, and distinctness of natural aggregates, while consistence refers to the force required to rupture soil material.

Consistence may be described under moisture conditions of wet, moist, or dry soil. When the soil material is wet, consistence is described by its stickiness or plasticity. Consistence when soil is moist is characterized by its tendency to break into smaller masses, but its ability to cohere again when pressed together. The consistence of soil material when dry is characterized by brittleness, maximum resistance to pressure, and inability of crushed material to cohere again when pressed together.

E. Soil Fertility and Productivity

Soil fertility is the ability of the soil to provide nutrients for plant growth. Regardless of the level of soil fertility, plant food must be returned to the soil if the soil is to stay fertile. As plant nutrients in soils decrease, the plant growth declines.

The productivity of a soil is the present capability of that soil for producing a specified plant or sequence of plants, under a defined set of management practices. It is measured in terms of outputs, or harvests, in relation to production inputs-fertilizer, etc., for a specific kind of soil.

The capability of a soil under a particular system of management is dependant upon such factors as the soil's natural fertility, organic matter content, texture, structure, and climate.

SOIL TEXTURAL CLASSES

SAND — DRY: LOOSE AND SINGLE GRAINED; FEELS GRITTY. MOIST: WILL FORM VERY EASILY-CRUMBLED BALL. SAND--85-100%, SILT--0-15%, CLAY--0-10%.

LOAMY SAND — DRY: SILT AND CLAY MAY MASK SAND; FEELS LOOSE, GRITTY. MOIST: FEELS GRITTY; FORMS EASILY-CRUMBLED BALL; STAINS FINGERS SLIGHTLY. SAND--70-90%, SILT--0-30%, CLAY--0-15%.

SANDY LOAM — DRY: CLODS EASILY BROKEN; SAND CAN BE SEEN AND FELT. MOIST: MODERATELY GRITTY; FORMS BALL THAT CAN STAND CAREFUL HANDLING; DEFINITELY STAINS FINGERS. SAND--43-85%, SILT--0-50%, CLAY--0-20%.

LOAM — DRY: CLODS MODERATELY DIFFICULT TO BREAK; MELLOW, SOMEWHAT GRITTY. MOIST: NEITHER VERY GRITTY NOR VERY SMOOTH; FORMS A FIRM BALL; STAINS FINGERS. SAND--23-52%, SILT--28-50%, CLAY--7-27%.

SILT LOAM — DRY: CLODS DIFFICULT TO BREAK; WHEN PULVERIZED FEELS SMOOTH, SOFT AND FLOURY, SHOWS FINGERPRINTS. MOIST: HAS SMOOTH OR SLICK "BUTTERY" OR "VELVETY" FEEL; STAINS FINGERS. SAND--0-50%, SILT--50-88%, CLAY--0-27%.

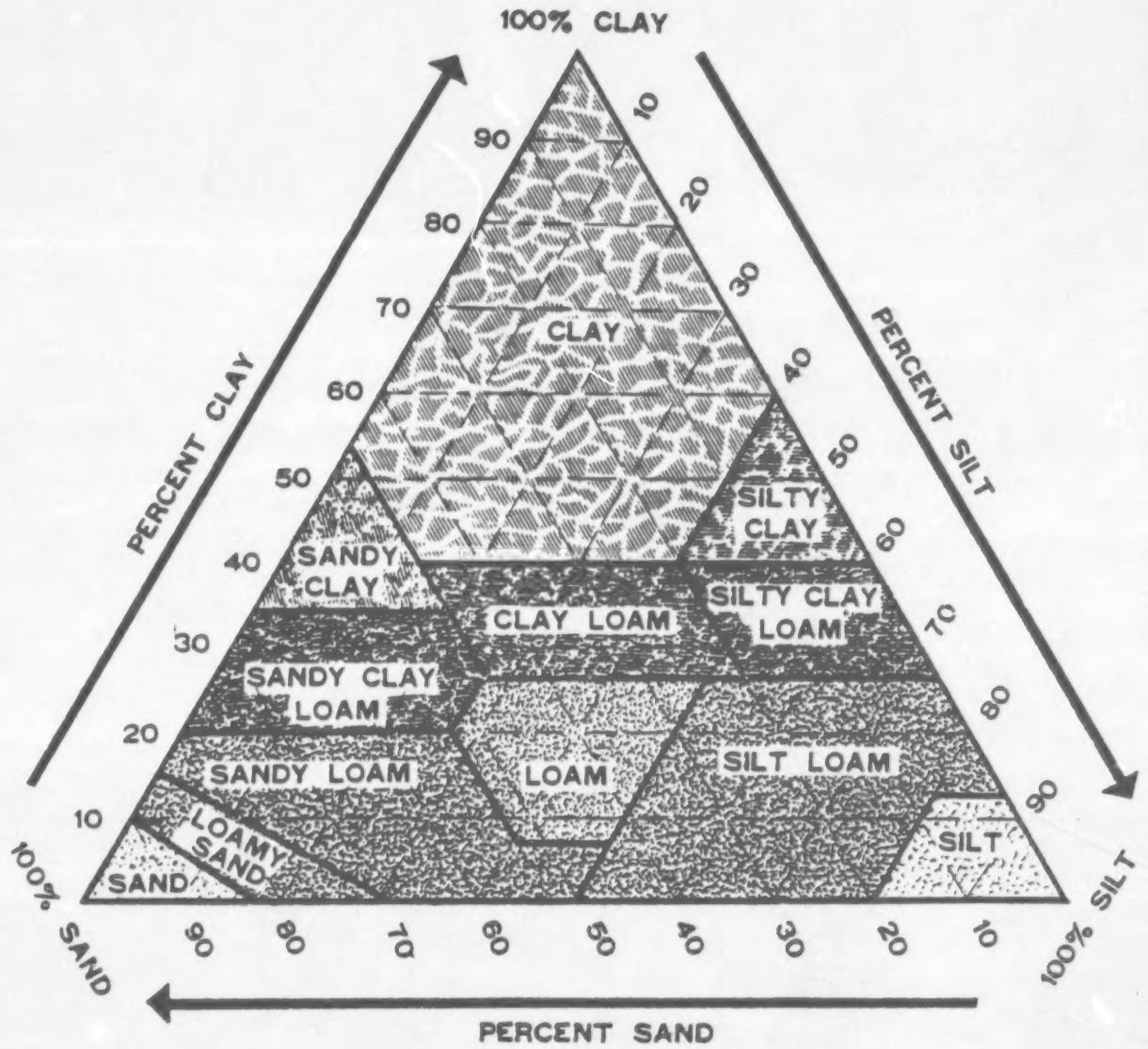
CLAY LOAM — DRY: CLODS VERY DIFFICULT TO BREAK WITH FINGERS. MOIST: HAS SLIGHTLY GRITTY FEEL; STAINS FINGERS; RIBBONS FAIRLY WELL. SAND--20-45%, SILT-15-53%, CLAY--27-40%.

SILTY CLAY LOAM — SAME AS ABOVE BUT VERY SMOOTH. SAND--0-20%, SILT--40-73%, CLAY--27-40%.

SANDY CLAY LOAM — SAME AS FOR CLAY LOAM. SAND--45-80%, SILT--0-28%, CLAY--20-35%.

CLAY — DRY: CLODS CANNOT BE BROKEN WITH FINGERS WITHOUT EXTREME PRESSURE. MOIST: QUITE PLASTIC AND USUALLY STICKY WHEN WET; STAINS FINGERS. (A SILTY CLAY FEELS SMOOTH, A SANDY CLAY FEELS GRITTY.) SAND--0-45%, SILT--0-40%, CLAY--40-100%.

Soil Triangle



TM - 2

CATEGORIES FOR CLASSIFYING STRUCTURAL AGGREGATES OF SOILS

Type of Soil Structure

(shape & arrangement of aggregates)

1. GRANULAR
2. PRISMATIC
3. BLOCKY
4. PLATY

Class of Soil Structure

(size of aggregates)

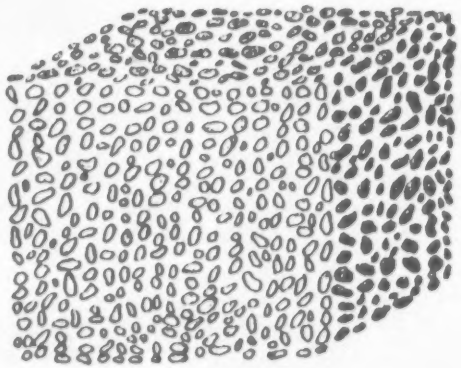
1. COARSE
2. MEDIUM
3. FINE

Grade of Soil Structure

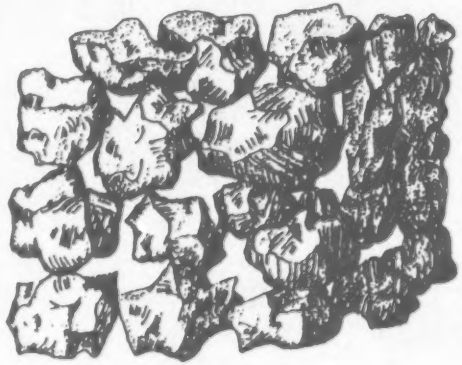
(strength of aggregate)

1. STRUCTURELESS
2. WEAK
3. FRIABLE
4. FIRM

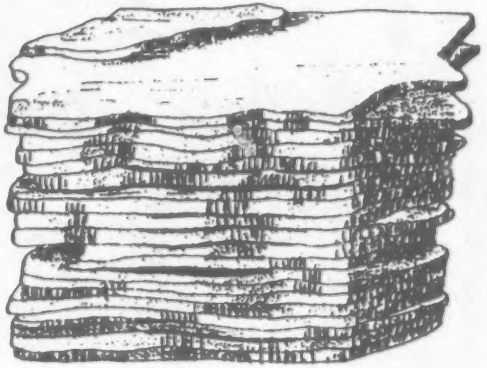
Soil Structure



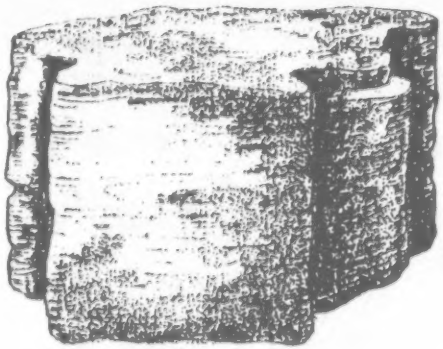
SINGLE GRAIN



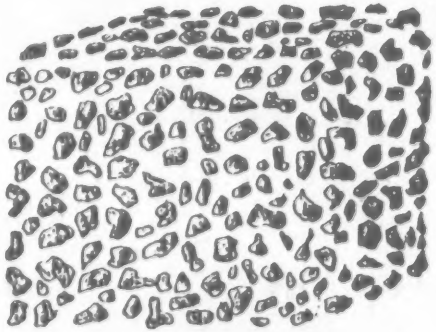
BLOCKY



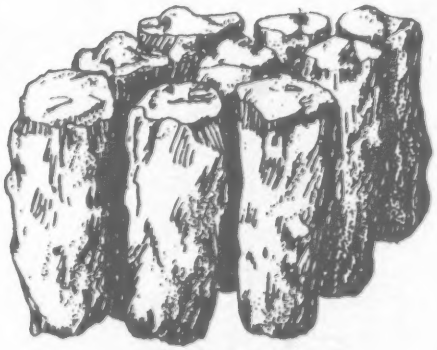
PLATY



MASSIVE



GRANULAR



PRISMATIC

Soil Science

Topic 3: Soil Classification

Note: A map of the United States showing the kinds of soils, orders, suborders, and great groups is available from the United States Geological Survey, 1200 South Eads Street, Arlington, Virginia 22202.

*All terms underlined are included in the "Glossary of Terms."

I. Soil Classification

In order for soil scientists to study soils, there had to be some system of soil classification and identification. The scientist recognizes a soil by its features, the same way an individual is recognized.

Classification consists of an orderly grouping of defined kinds of soils into classes in a system designed to make it easier to remember their characteristics. The purpose of the classification of soils is to place them into suitable categories to study and interpret their interrelationships or inherent problems. Land use and other principles of treatment can then be determined and applied to each class of land.

Since the features of the soil are found in the soil profile, one must be familiar with the soil profile in order to classify soils.

II. Soil Profile

Transparency No. 1

A soil profile is a vertical section of the soil extending down through all of its horizons-"A," or topsoil; "B," or subsoil; and "C," or parent materials, which is the layer just above solid-earth bedrock. These horizons often merge with one another, and therefore may not be easily identified. The horizons of a particular soil vary in one or more properties such as texture, color, structure, consistency, porosity, and reaction. By studying these variations and properties, it is possible to identify soils.

The depth of each horizon in a soil profile varies in accordance with the several factors which originally influenced its formation. Some are thick, some thin, varying from less than an inch to several feet.

Transparency No. 2

Soil horizons vary in thickness and generally are merged with one another; therefore, the horizons usually lack sharp boundaries. Most soil profiles include three master horizons, identified by the letters A, B, and C; however, some soils lack a B horizon and are said to have AC profiles. Eroded soils may not have an A horizon, and in some cases the B horizon may have eroded away.

"A" HORIZON or TOPSOIL - The soil on the surface makes up this horizon, unless this layer has been completely eroded away. The "A" horizon is the soil layer where life is most abundant in the form of plant roots, bacteria, fungi, and insects. It is the layer usually cultivated for crops.

All of the master horizons may be subdivided in the scientific study of soils. Such subdivisions are identified by the proper letter plus a subscript number, thus: A_1, A_2, A_3, etc. The subdivisions of master horizons provide clues to the processes of soil formation and are important to the use and management of the soil.

The subdivisions of the "A" horizon are as follows:

A_{00} - Loose leaves and organic debris, largely undecomposed.
A_0 - Organic debris partially decomposed or matted.
A_1 - A dark-colored horizon with a high content of organic matter mixed with mineral matter.
A_2 - A light-colored horizon of maximum eluviation. Prominent in podzolic soils.
A_3 - Transitional to B, but more like A than B. Sometimes absent.

"B" HORIZON or SUBSOIL - The "B" horizon is the layer of soil lying just beneath the "A" horizon and is referred to as the subsoil. It contains more clay and less organic matter than the topsoil.

The "B" horizon forms partly by the downward movement of the finer soil particles during the percolation of soil water. Organisms and plant residues have very little influence on the formation of the "B" horizon. Neither does cultivation, except where there is some mixing of topsoil with the "B" horizon. Therefore, the characteristics of the subsoils are usually an accurate index to their true nature and origin.

The subdivisions of the "B" horizon are as follows:

B_1 - Transitional to B, but more like A than B. Sometimes absent.
B_2 - Maximum accumulation of silicate clay materials or of iron and organic matter; maximum development of blocky or prismatic structure; or both.
B_3 - Transitional to C.

The combined "A" and "B" horizons, the major part of a soil profile, are called the solum or true soil. This is the area that supports plant growth.

"C" HORIZON or PARENT MA. RIAL - The "C" horizon is the layer of loose perent material lying between the "B" horizon and earth bedrock. Parent materials are important not only because they affect the formation of subsoils above them, but because they are directly associated with the texture and natural fertility of any soil. The "C" horizon has less living matter than overlying ones and is therefore lower in organic matter. It is commonly lighter in color than "A" and

"B" horizons.

The subdivisions of the "C" horizon are as follows:

G - Horizon G for intensely gleyed layers, as in hydromorphic soils.

Cca and Ccs - The weathered parent material. These horizons are layers of accumulated calcium carbonate and calcium sulfate found in some soils.

"D" HORIZON or BEDROCK - The "D" horizon is any stratum underneath the soil, such as hard rock or layers of clay or sand, that are not parent material, but which may have significance to the overlying soil.

III. Classifying Soils

People have always classified soils by their colors, water holding capacity, or by some other characteristic, but this wasn't very specific or exact.

Transparency No. 3

To take advantage of soil research and to increase yields, soil scientists had to classify soils according to a scheme. The soil classification scheme being used at the present time is grouped as follows:

Order	Subgroup	Class
Suborder	Family	Type
Great Group	Series	Phase

The following is an explanation of each of the above groups:

A. Order - The soil order is the highest and most general level of soil classification. At present, 10 soil orders are used. The orders reflect in a general way geographic distribution of soils similar in degree and kind of horizon development. ENTICOLS, for instance, lack well defined genetic horizons, while ULTISOLS are weathered to an advanced stage and have horizons strongly contrasting in color.

B. Suborder - The suborder, a division of the soil order, groups soils which have common charateristics reflecting uniformity in the soil forming factors. For example, AQUALFS are seasonally wet ALFISOLS that are gray and mottled.

C. Great Group - The great group is a further subdivision of the suborder, and provides for grouping soils largely on the presence or absence of diagnostic horizons and their arrangement. For instance, MOLLISOLS that contain significant alluvial clay are called ARGIUSTOLLS.

D. Subgroup - At the subgroup level soils with properties typical of the great group are classified together.

E. Family - Soils similar in texture below the surface layer and similar in clay mineralogy, temperature, and other properties are grouped in the same soil family.

F. Series - Soils essentially uniform in kind, thickness, and sequence of horizons and very similar physically, chemically, and mineralogically are called a soil series. This is the lowest category of formal soil classification. Willamette-Woodburn is an example of a series name common to the Willamette Valley. The series name usually derives from the place where the soil was first found.

G. Textural Class - The textural class is determined by the percentage of sand, silt, and clay in the surface layer of the soil. The surface texture is allowed to vary more than other properties.

H. Type - There are approximately 80,000 soil types in the United States, and the series name combined with the textural name is the soil type. An example of soil type would be Amity, silty clay loam -- which is a member of the Willamette-Woodburn soil series.

I. Phase - Phases are individual areas of soil types which have differences in slope, stoniness, and thickness due to erosion. For example, Pullman clay loam, 0-1 percent slopes in a soil phase which may be found in northeastern Oregon.

Transparency No. 4

Differences among soil types occur even within the boundaries of small farms. Each soil type can be defined by a description of the typical profile, the allowable differences from that profile, and other features such as slope, stoniness, and physiographic position.

Similar soil types always occur in a definite geographic area and are in the same formations. In other words, they always choose the same neighbors. The individual bodies of neighboring soil types within a farm fit together like the pieces of a jigsaw puzzle as shown in the illustration. However, soil types are not set apart as distinctly as the sketch suggests; they grade into one another without sharp boundaries between them. This is one reason why soil appears to be a continuous mantle over the land surface.

IV. Soil Surveys

Soil classification and identification are important in order to make decisions necessary to secure maximum production. The information obtained by soil scientists in classifying and identifying various soils is recorded in a soil survey. A soil survey is a map of a farm that designates the kinds and location of soils. It also gives a description of the soils along with suggestions as to their use and management.

Soil surveys should be made by an experienced person such as a local Soil Conservation Services (S.C.S.) technician. The first step in making the survey is to secure an aerial map of the area to be surveyed. After a thorough study of the map, the technician takes soil samples and determines the texture, color, and thickness of each layer of soil in order to classify and identify the soils. To complete the survey, the technician draws lines on the aerial photograph to designate changes in soil. The soil map will also designate soil types, erosion, slope, and land capability classes. All of this information is necessary for proper soil management and maximum production.

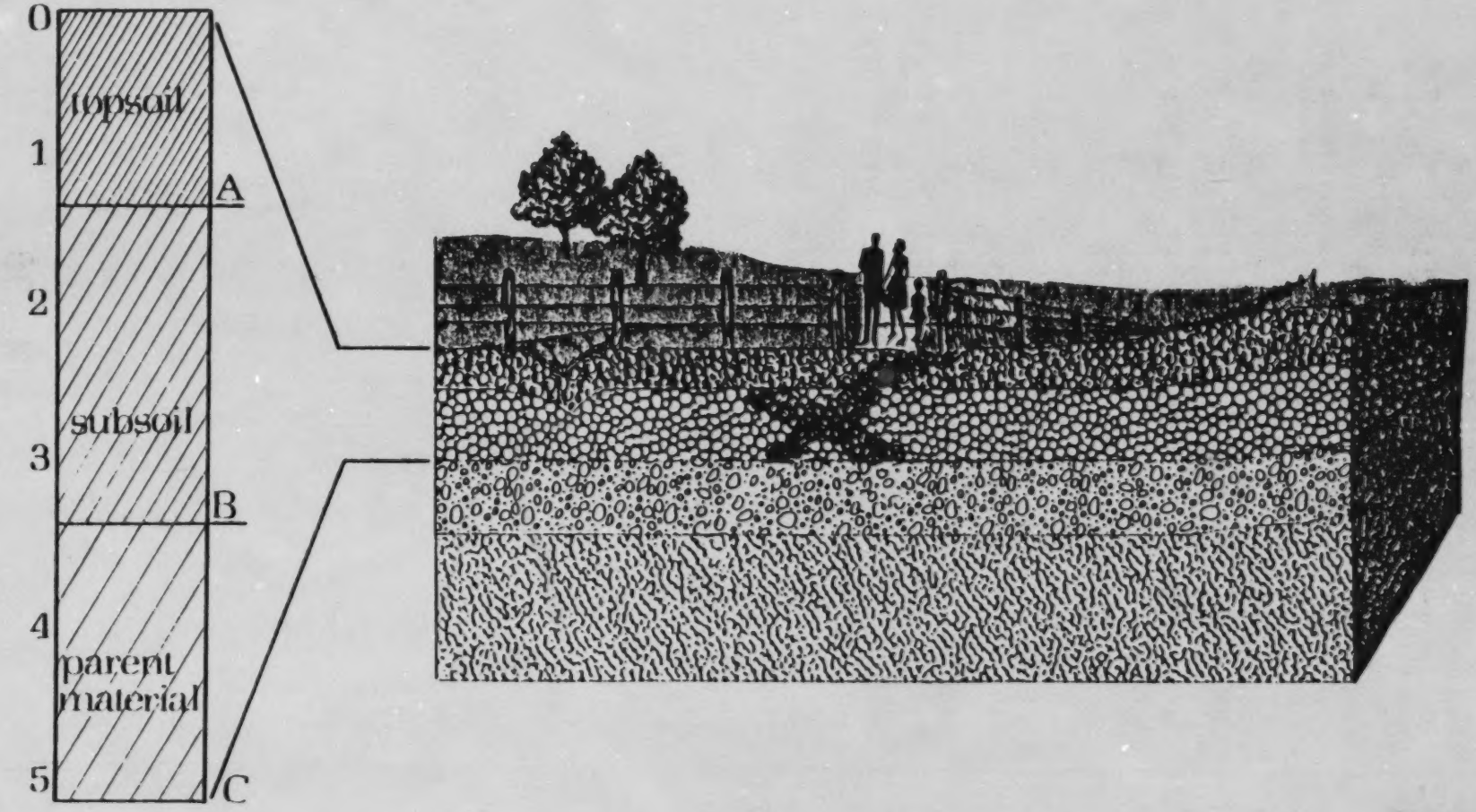
V. Conservation Plans

Transparency No. 5

In order for the landowner to derive the maximum benefit from a soil survey report, they should secure the services of the local Soil Conservation Service personnel to assist them in developing a soil and water conservation plan for their farm or ranch. The conservation plan consists of a plan map (aerial photograph) of the individual farm and a soil survey map. The conservation plan represents a cooperative agreement between the landowner and the Soil Conservation Service District. It reflects the landowner's decisions on how to use the land based on sound land use and economy of operations.

The conservation plan, after being completed will serve as a guide for soil and water conservation improvements to be carried out by the landowner for several years. The Soil Conservation Service then provides technical assistance at no cost to the landowner for putting the plan into operation and in making needed changes in the plan.

SOIL PROFILE



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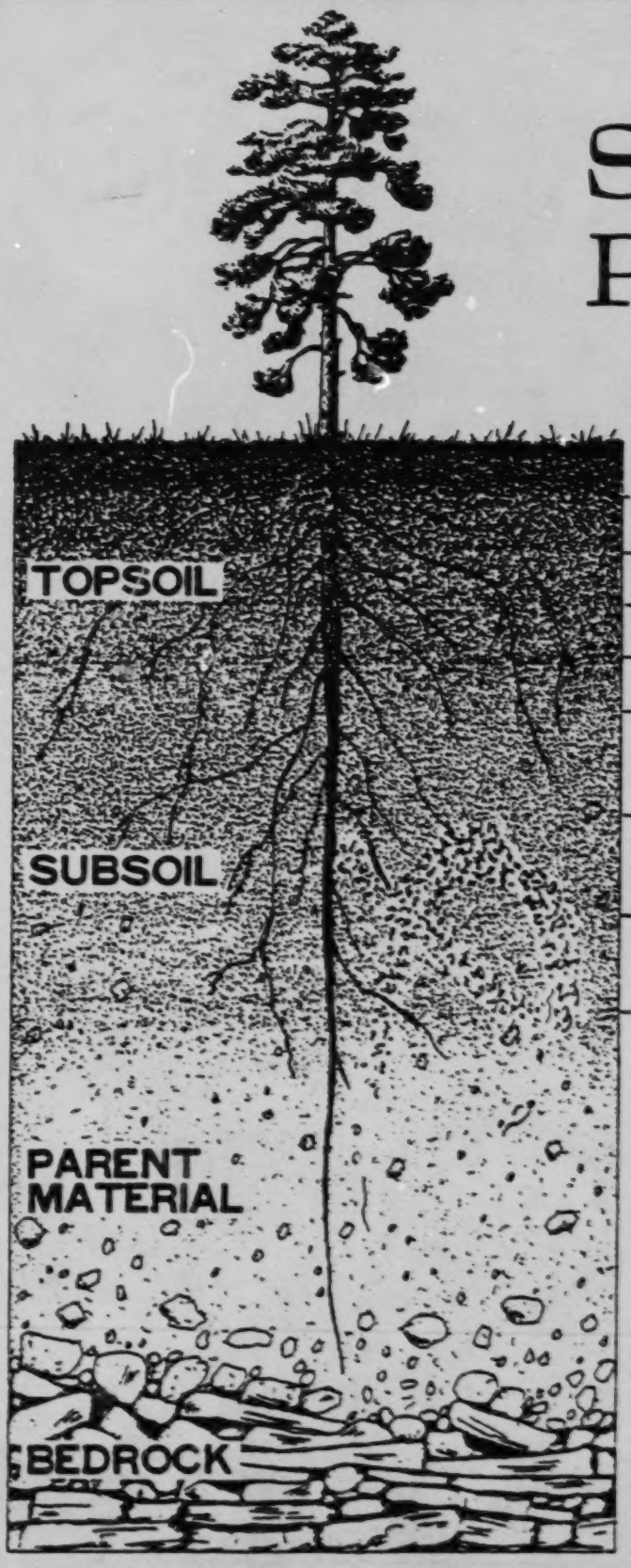
PM - 1

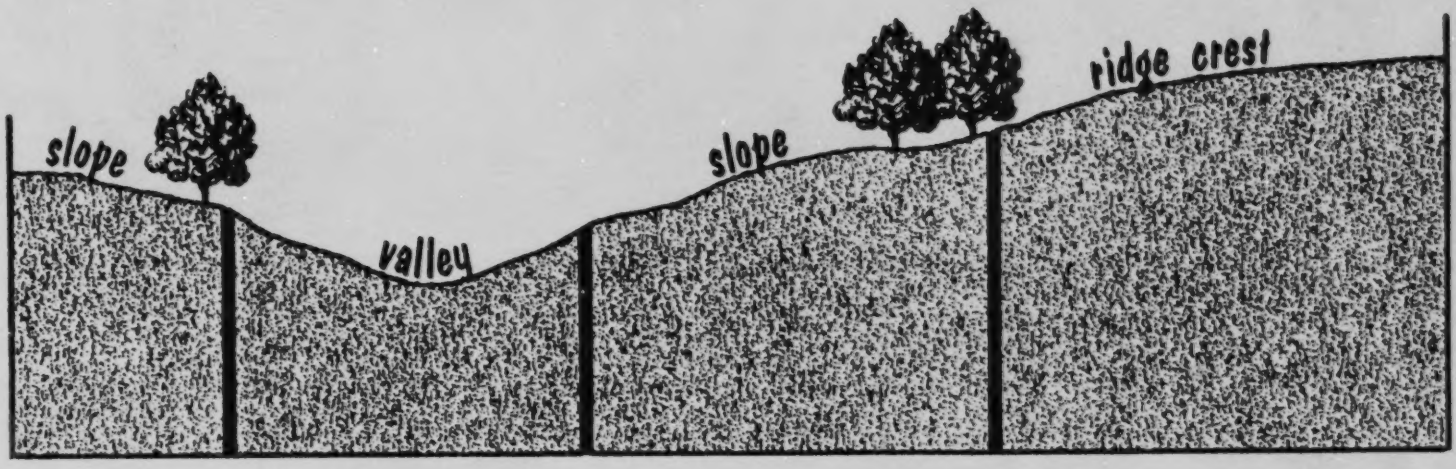
Soil Profile



SCIENTIFIC CLASSIFICATION OF A SOIL SAMPLE

ORDER	ARIDISOLS
SUBORDER	ARGIDS
GREAT GROUP	DURAGRIDS
SUBGROUP	XEROLLIC
FAMILY	FINE, LOAMY, MIXED, MESIC
SERIES	OCHOCO
TEXTURAL CLASS	SANDY CLAY LOAM
TYPE	WHEELER FINE CLAY LOAM
PHASE	1-3 PER CENT SLOPES

How Soil Types Fit Together



STEIWER
(COAST RANGE SLOPE)

AMITY - DAYTON

WILLAMETTE

JORY
(CASCADE RANGE SLOPE)

SOIL & WATER CONSERVATION PLAN

A. CONSERVATION PLAN MAP (AERIAL PHOTOGRAPH)

B. SOIL & WATER CAPABILITY MAP

C. RECORD OF COOPERATOR'S DECISIONS & PROGRESS IN APPLICATION

1. FIELD NUMBERS
2. LAND USE & TREATMENT
   a. PLANNED
   b. APPLIED

D. ANNUAL GRAZING PLAN

E. FORAGE INVENTORY

F. FARMER - SOIL CONSERVATION DISTRICT COOPERATIVE AGREEMENT

Soil Science

Topic 4: Soil Sampling

Suggested Procedure and Activities: It may be helpful to devote one class period to actually taking a soil sample in the field.

*All terms underlined are included in the "Glossary of Terms."

I. Introduction

The soil in some respects is like people; it needs a periodic check up. It is through this periodic check up, along with good management practices, that the highest return on the investment in fertilizer and lime can be acquired. In order to know the proper amount of fertilizer and the lime the soil needs, the soil should be tested. The soil test will provide a scientific basis, rather than a haphazard hit-and-miss basis, for correct usage.

There are thousands of soil samples taken each year. The results of the sample test will indicate the necessary facts and recommendations concerning the soil. The test results will make available facts that will indicate whether the soil needs:

A. Lime
B. Nitrogen
C. Phosphorus
D. Potassium

The test will further determine the levels of calcium, magnesium, zinc, iron, manganese, and the percent of organic matter in the soil. Also, it may indicate if the soil has sufficient salt content to create a salinity hazard.

In addition to the above information obtained from the chemical test, the soil testing laboratories analyze the information supplied from the landowner and suggest fertilization and liming rates compatable with the desired production.

II. The Proper Time to Take Soil Samples

A. Samples may be taken any time during the year.
B. The sample should be taken when the soil is dry enough to work readily.
C. The season of the year may assist in obtaining the test results.
   1. It is recommended to take samples in the fall for spring planted crops.
   2. Sample in the summer for fall planted crops.
D. Take samples well in advance of the time the crop is to be planted. This practice will allow the testing laboratory ample time to return the results.
E. Soil samples should be made as a general rule:
   1. Once a year, for continuous row crops.
   2. Once per rotation of dairy farm rotation.

III. Procedure in Taking a Soil Sample

Transparency No. 1

A. Get Complete Information - There are two important sayings:

(1) Don't guess, soil test.
(2) The soil test is only as good as the soil sample.

When taking a soil sample, be sure you have the information needed for taking the sample. Information may be obtained from the vocational agriculture teacher, extension agent, or other local agricultural authorities in the county. The instructions on how to take a proper soil sample should be studied and followed very carefully. OSU Extension Circular No. 628, "How to Take a Soil Sample" should be followed exactly.

B. Select Proper Sampling Tools - A soil probe or auger is highly recommended for obtaining soil. If the soil probe or auger is not available, a garden trowel or spade may be used. A perfectly clean pail (bucket) is recommended for collecting the soil from each sample area. Feed dealers and agricultural authorities often have these tools to loan.

Transparency No. 2

C. Watch for Unusual Areas - When taking a soil sample, avoid old fence lines, dead furrows, old manure and lime piles, terrace channels, snow fences, back furrows, wind breaks, wet spots, areas near trees, areas near the boundaries between slopes and bottomland, and areas near roads.

D. The field to be sampled should be divided into different areas. It is usually recommended that each sample represent an area of not more than 8-12 acres. In areas where soil is uniform, it may be possible to use larger acreage per sample area. Be sure and sample seperately all areas that have different crop growth, soil color, and past management. It would be wise to avoid all areas that are too small to be lined or fertilized seperately.

Transparency No. 3

E. Take composite samples of soil from each area. The first thing that should be done after a sampling area is designated is to remove the surface litter from the spot sample that is to be made. Soil should be taken from 10 to 15 spots in each area. As the soil is taken, it should be placed in a clean pail. The soil that is taken from a row crop field should be obtained between the rows and not from rows. If the samples are being taken on pasture areas take only about the top two to four inches of the topsoil.

F. When a sample is taken with a spade, a V-shaped hole should be dug to plow depth. Remove a 1-inch slice of soil from the face of the hole. Remove all except the middle inch of the soil slice. Place the one inch slice in a clean pail.

Transparency No. 4

G. Mix Soil from Sample Spots - The soil taken from the sampling spots in each area should be mixed well in a clean pail. It is advisable to remove as much foreign matter as possible without changing the representative sample.

H. Fill out the Information Sheet - The extent of accuracy of the test results will depend not only upon the composite sample but also the information given about the sample. For instance, fertilizer rates will depend on the soil type, crop to be grown, normal moisture situation and expected yield.

Transparency No. 5

I. Identify Samples and Keep Records - Many time it is good to make a rough sketch of the areas of fields sampled and correspond them by number to an assigned number on the sample bag.

J. Follow Recommendations - The soil test will be of little value if it is not followed. The soil test results and recommendations should be studied carefully. The fertilizer dealer, vocational agriculture teacher, extension agent, or other agricultural authority in the community can be of great assistance in helping you properly carry out your program.

IV. Where to Send Soil Samples for Testing

Wrap soil sample bag securely and mail to:

Soil Testing Laboratory
Oregon State University
Corvallis, Oregon 97331

V. Sample Carton and Information Sheet (s)

Soil sampling information on the sample bag should be filled out completely. The information sheet should be filled out as completely as possible. Be sure to number each sample and keep a record of fields sampled. Mail the information sheet along with the sample. Include a check to cover the cost of the sample. Sample bags, information sheets, and sampling instructions can be obtained by contacting your local extension agent.

References

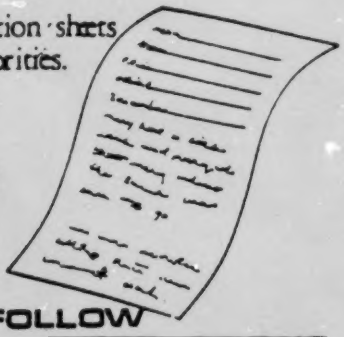
1. "How to Take a Soil Sample", Ext. Cir 628, Oregon State University, Corvallis, Oregon 97331.

2. "Principles of Soil Sampling", Western Regional Publication. WREP 9, Cooperative Extension Service, Oregon State University, Corvallis, Oregon 97331.

SOIL → Sampling

A

Obtain cartons and information sheets from local agricultural authorities.



FOLLOW INSTRUCTIONS CAREFULLY

B

Soil Probe

Soil Auger

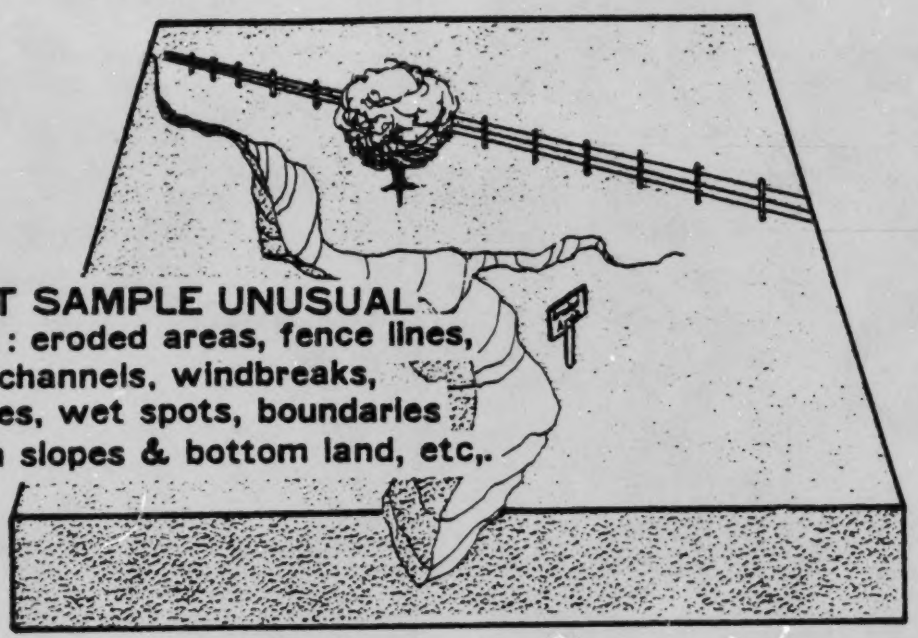
Spade or Shovel

Garden Trowel

SAMPLING TOOLS

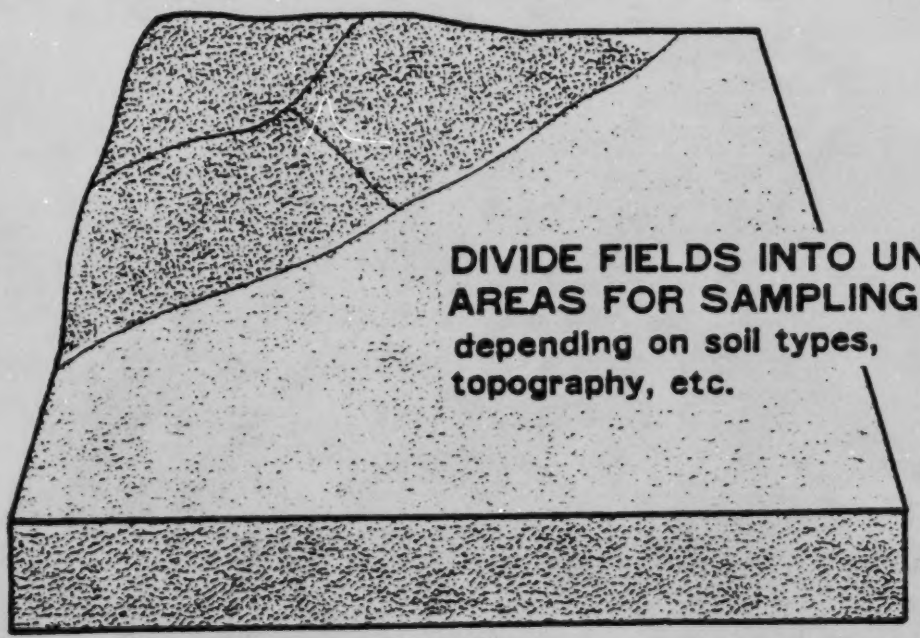
SOIL SAMPLING

C



DO NOT SAMPLE UNUSUAL AREAS : eroded areas, fence lines, terrace channels, windbreaks, near trees, wet spots, boundaries between slopes & bottom land, etc,.

D

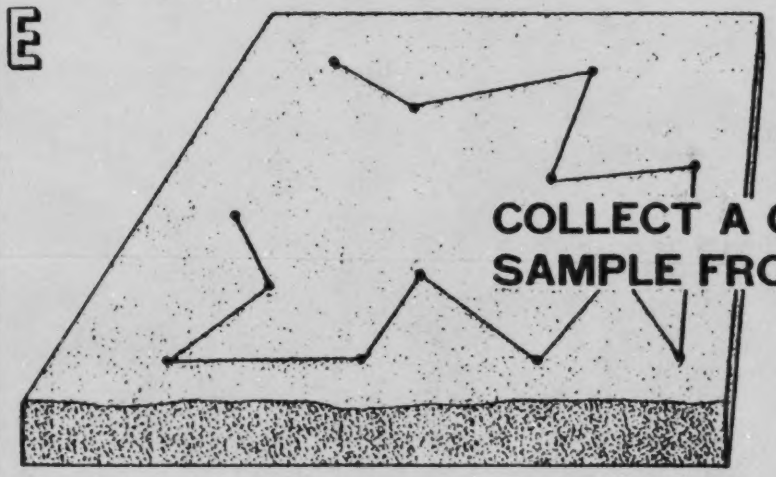


DIVIDE FIELDS INTO UNIFORM AREAS FOR SAMPLING
depending on soil types, topography, etc.

SOIL SAMPLING

PASTURE AREA

E

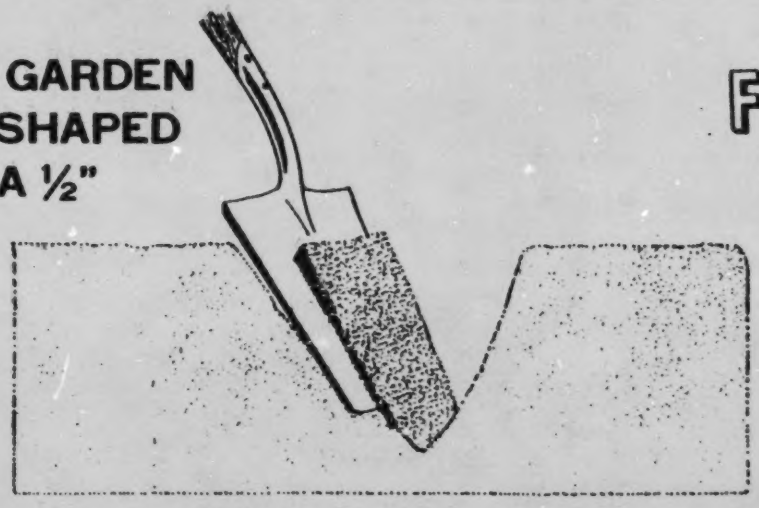


FIELD CROP AREA

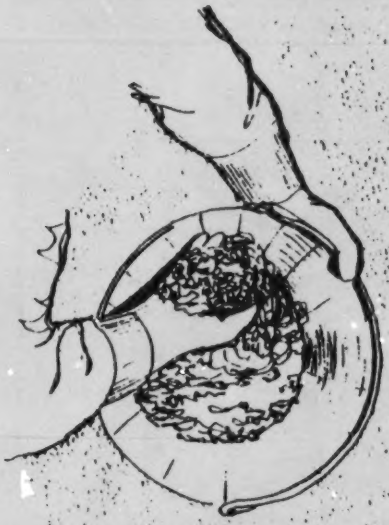
COLLECT A COMPOSITE SAMPLE FROM 10—15 PLACES

WITH A SPADE OR GARDEN TROWEL DIG A V—SHAPED HOLE, THEN TAKE A ½" SLICE FROM THE SMOOTH SIDE OF THE HOLE

F

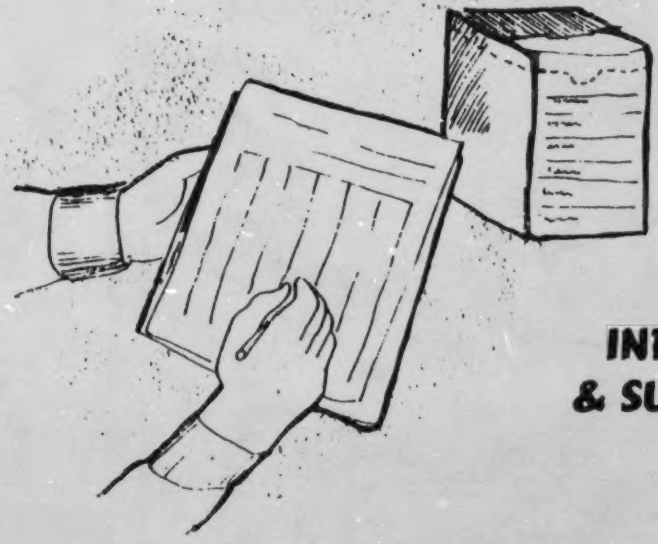


SOIL SAMPLING



G

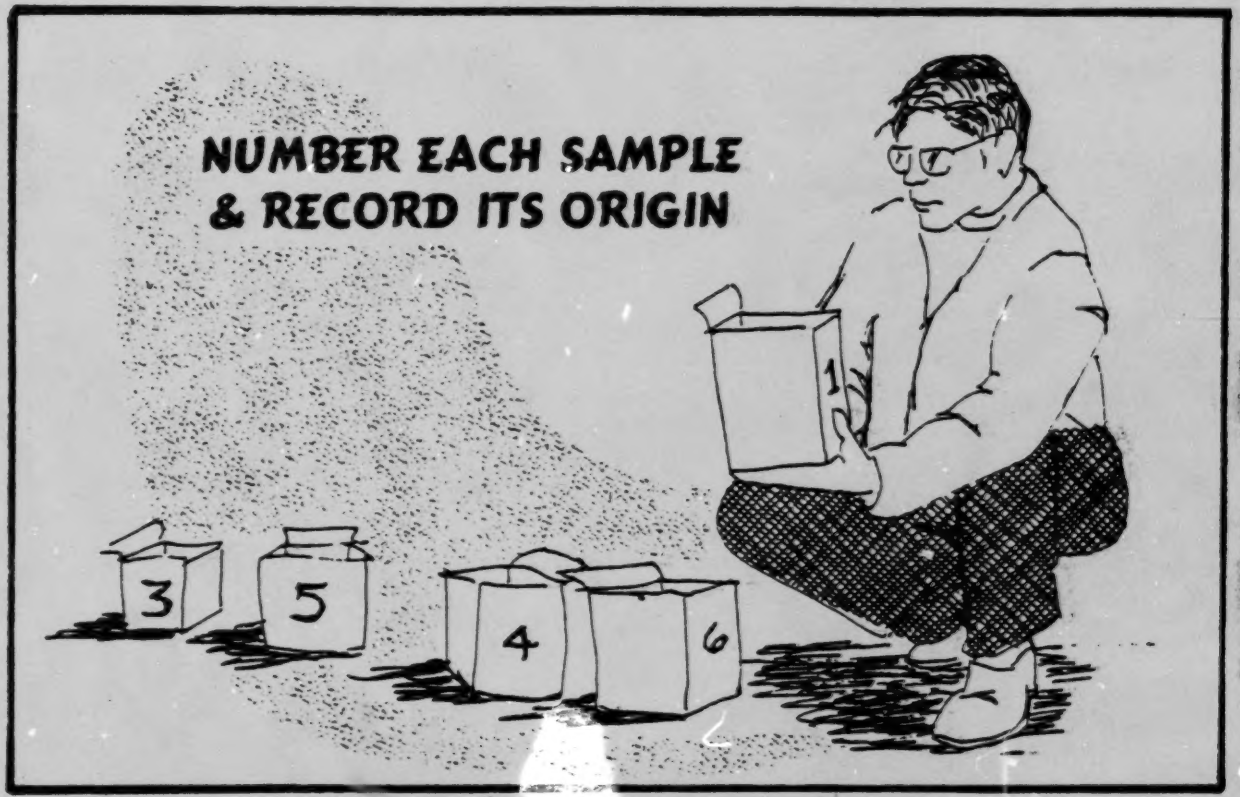
MIX SAMPLES IN A CLEAN CONTAINER



H

COMPLETE INFORMATION SHEET & SUBMIT WITH SAMPLE

SOIL SAMPLING



FOLLOW SOIL TEST RECOMMENDATIONS

Soil Science

Topic 5: Importance of Organic Matter

I. What is Soil Organic Matter?

Organic matter in the soil consists of products from decaying plant and animal materials. These materials in varying stages of decomposition include: plant residues of crops, grasses, weeds, and trees; animal residues from decaying carcasses and excrements; and other biological organisms such as bacteria, fungi, and protozoa.

Soil humus represents an advanced stage in the decomposition of organic material. It is the more stable part of well-decomposed organic matter in mineral soils.

Transparency No. 1

The organic matter content of a typical soil with good physical structure may vary from 0.5 to 5 percent. For many soils organic matter is the life body, especially those with sandy, low clay content. It affects the ion exchange capacity, water infilteration rate, water holding capacity, and physical structure of soils.

II. Composition of Soil Organic Matter

A. Physical and Biological Properties

All organic material added to the soil breaks down through the process of mineralization; however, some residues are more resistant than others; i.e., lignin, which is a major component of the woody parts of plant tissues, is highly resistant to being broken down into the simple mineral compounds. Humus, being a relatively stable stage in the breakdown of organic matter, is usually recognized by its brown to black color. It is practically odorless and has no particular form, representing only a small percentage of the total soil volume. Humus has similar physical properties to clay particles in that it can absorb considerable moisture in the soil. Certain of the chemical elements, especially nitrogen, become attached to humus in the soil, causing these elements to become more available for plant food.

Manures and other forms of organic materials, while breaking down into humus, release their nutrients for plant use. Bacteria, fungi, and other microorganisms feeding on the raw organic materials in the soil are responsible for the breakdown.

Since soil nitrogen is stored largely in the humus, the amount of nitrogen in the soil is almost in direct proportion to the humus content of the soil. In other words, the amount of nitrogen in the soil is an index to the percentage of organic matter in the soil.

Under normal conditions the content of organic matter in the soil remains fairly constant, unless the top soil is removed by erosion. However, the amount of organic matter may be affected by a number of conditions beyond the control of the farmer.

1. Soil texture influences the rate of decomposition. (Sandy soils allow more rapid decompostition because of greater aeration).
2. Humid conditions promote faster decay of organic matter.
3. High temperatures stimulate greater activity of micro-organisms.

Considering these factors, one could conclude that sandy soils in an area of high humidity and above average temperatures would generally be rather low in organic matter. On the other hand, clay-type soils in a cool climate would usually be higher in organic matter. Any one or all of these factors will influence organic matter content.

B. Chemical Properties

Plant and animal tissues are very complex in their chemical makeup. Their breakdown or decomposition, brought about by the soil organisms, will reveal varying percentages of chemical substances, depending on the kind of plant and its state of decomposition.

The starches, sugars and water soluble proteins are decomposed first. Next are the fats, oils, and waxes which are more water resistant and therefore are broken down more slowly. The last substance to decompose is lignin, which is the major component of humus. Lignin is very resistant to decomposition.

Lignin and protein are found in largest quantities, each varying from 25 to 50 percent. The percentages of lignin and protein vary in different plant species; however, as plants reach maturity the percent of lignin increases and the percent of protein decreases.

III. Functions of Organic Matter

Organic matter serves many purposes in the soil. Consider the following benefits of organic matter in a soil depending on its stage of decomposition.

A. Fresh Organic Matter (green manure, crop residues, surface mulches, etc.):

1. Reduces the impact of falling raindrops and permits water to seep slowly into the soil, thus reducing surface runoff and erosion.
2. Reduces losses of soil by wind erosion.
3. Supplies food for soil life such as ants, earthworms, and rodents.
4. Makes soil phosphorus more available in acid soils.
5. Lowers soil temperatures in hot weather and increases it in the cold weather.
6. Reduces evaporation losses of soil moisture.

B. Decomposing Organic Matter

7. Produces slimes and microbial gums which help to form and stabilize desirable soil structure.

8. Releases organic acids which help to dissolve minerals making them more available for growing plants.
9. Makes available more water capacity for plant growth.
10. Supplies nutrients, hormones, and antibiotics needed by growing plants.
11. Provides channels through which new plant roots can grow more easily.
12. Provides a storehouse for the exchangeable cations - calcium, magnesium, and potassium.
13. Helps to buffer soils against rapid chemical changes caused by the addition of lime and fertilizers.
14. Reduces the toxicity of plant poisons that build up due to continuous use of some insecticides and pesticides.
15. Reduces the severity of attack by a soil borne fungal disease in the case of cotton root rot.

IV. Supplying Organic Matter to the Soil

No exact amount of organic matter is required to support plant growth and maintain productivity. However, it is important to supply regular additions of residue to soils so that decomposition is continuous. This provides a constant supply of plant nutrients and contributes to the continuous improvement of soil structure.

A good residue management program is essential in supplying organic matter. It is also necessary to obtain efficient soil and water utilization and increased crop productivity. In soils being cultivated intensively the key to a good soil improvement progam is adequate fertilization to produce high yields, coupled with good residue management.

In most soils an estimated annual return of 4,000 or more pounds of dry, above ground residue is needed to maintain a break-even level of organic matter. The following transparency (No. 2) shows the estimates of the amounts of residue returned to the soil for selected crops.

Transparency No. 2

A fairly accurate method for estimating the amount of crop residue returned to the soil for oats, and wheat is as follows:

50 pounds of dry residue for each bushel (32 lbs.) of oats, and 100 pounds of dry residue for each bushel (60 lbs.) of wheat.

On grassland soils the roots of plants are the largest source of natural organic matter. For pasture or range soils an important factor in residue management is controlled grazing. Continuous over grazing of the forage quickly reduces the organic matter of these soils.

Other sources of natural organic matter are green manure crops and barnyard manure.

A green manure crop is any crop plowed back into the soil while it is still green. Green manure crops in the case of legumes add both organic matter and nitrogen to the soil.

Transparency No. 3

Barnyard manure is a valuable source of organic matter as well as microorganisms. Each ton of manure not only contains partially decomposed plant materials and dead bacteria but millions of live bacteria ready to convert these into humus and available plant nutrients. Manure also improves soil tilth, structure and moisture-holding capacity.

Many gardeners maintain a compost pile as a source of manure. Compost may be a mixture of manure, leaves, sawdust, straw, hay, peat, etc. along with lime and fertilizer materials.

V. Maintaining Soil Organic Matter

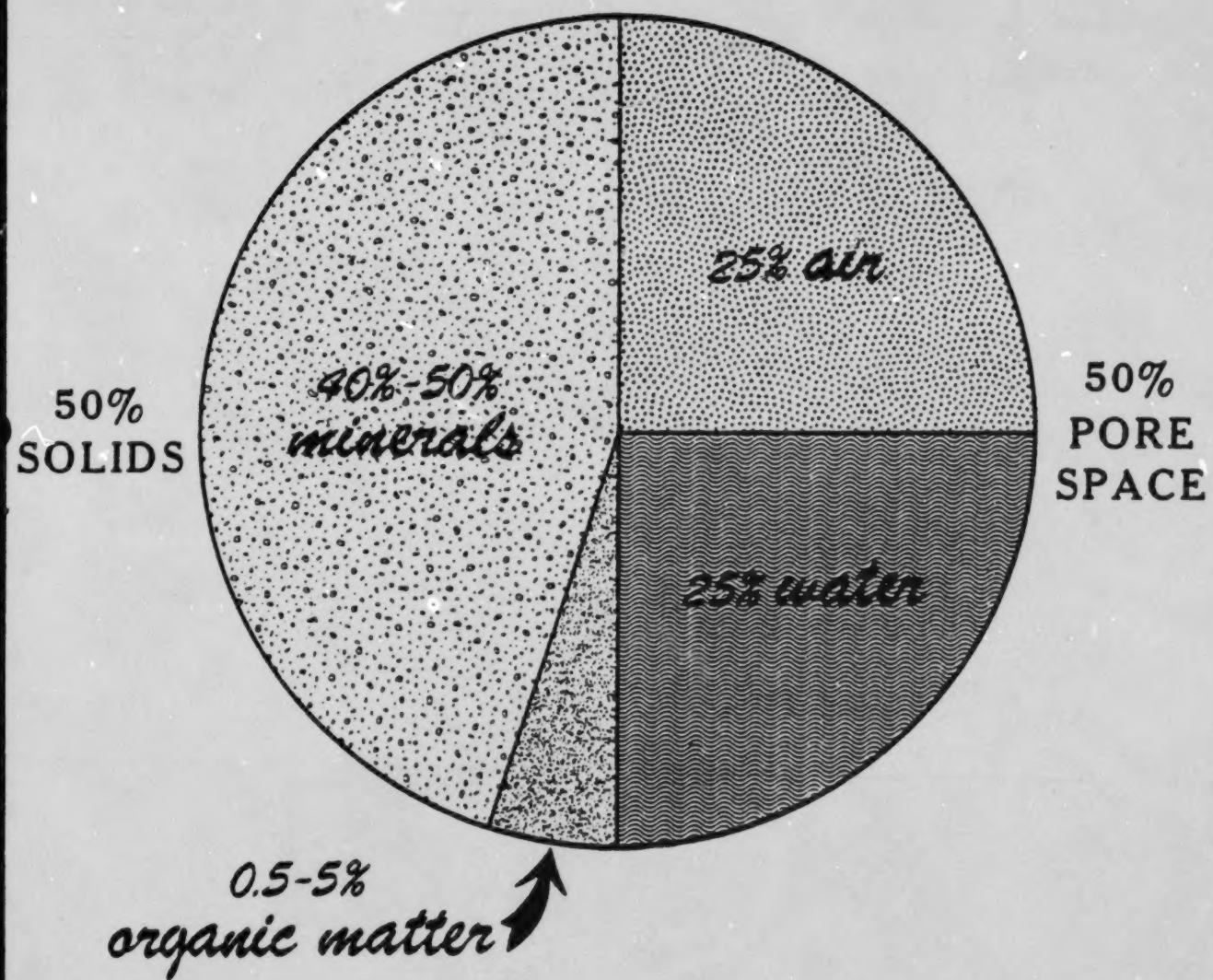
Since plants do not require an exact amount of organic matter, it is difficult to establish rigid requirements for desirable levels in soils. For this reason, it would be uneconomical to attempt to maintain a level of organic matter above that which is needed for profitable crop yields. As already stated, it is more important of supply regular additions of residue, so that decomposition is continuous.

Practices suggested for maintaining soil organic matter include:

A. Growing sod, cover, and green manure crops.
B. Utilizing all crop residues properly.
C. Conserving and applying manure.
D. Controlling erosion through good conservation practices.
E. Using commercial fertilizers when feasible to increase amounts of crop residues returned to the soil.

Remember, organic matter makes a significant contribution to soil productivity and should be maintained!

VOLUME COMPONENTS OF A TYPICAL SOIL WITH GOOD PHYSICAL STRUCTURE

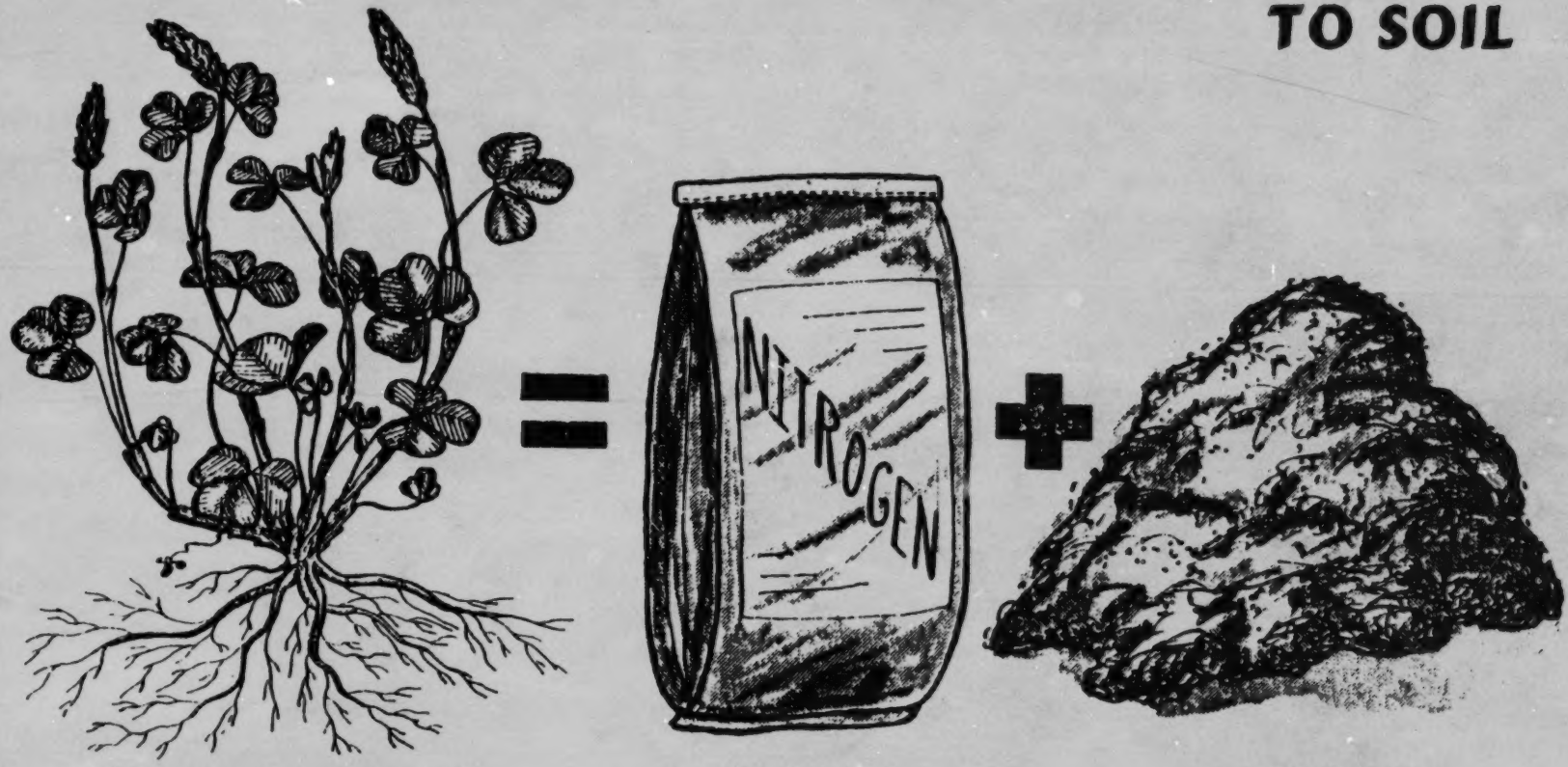


ESTIMATES OF CROP RESIDUES RETURNED TO THE SOIL

CROP	YIELD/ACRE	RESIDUE LB./ACRE
OATS	80 BUSHELS	4000
WHEAT	40 BUSHELS	4000

GREEN MANURE CROPS ADD

NITROGEN & ORGANIC MATTER TO SOIL



1 ACRE OF CLOVER (TOPS & ROOTS)

160 LBS. OF NITROGEN

2 TONS OF ORGANIC MATTER

TM - 3

Ag II - IV - 51

Soil Science

Topic 6: Basic Soil Nutrients

I. Influence and Composition of Soil Nutrients

Soil, in its natural condition, is a layer composed of a mixture of minerals, organic material, moisture, and air. Also, within this later of materials are found soil organisms such as bacteria, fungi, and worms.

The topsoil, which is the chief support of plant life on the earth, is created by the forces of nature -- the action of climatic conditions, along with plant and animal life. Averaging about seven inches in depth, the topsoil supplies vegetation with the raw materials needed as plant food. It is the source of 13 of the 16 chemical elements essential for plant growth. Twelve of the thirteen elements originated from the parent material from which the soil was formed. The total supply of plant nutrients in the soil is therefore of economic importance to the production of food and fiber.

The natural productivity of a particular soil will depend, to a large degree, upon the kind of rocks and minerals from which it was formed. Soils that were derived from parent materials containing limestone will contain sufficient amounts of calcium for most plant production. An example of this would be clay or clay loam soils formed from limestone. On the other hand, soils formed from sandstone (sandy soils) will usually be deficient in calcium. Most of our soils contain the 13 essential elements for plant production. These elements may or may not be in forms that can be used by the plants. Before the plant can use a mineral, it must be placed in a solution that makes it ready for absorption. Nature, through the action of soil organisms, water, and weak acids, has provided a means of changing the unavailable forms into less complex forms that can be used by plants. This action is slow, but does occur faster in some types of soils than in others. Also, the finer textured soils have the ability to store more soil nutrients than the coarser textured soils.

II. Classification of Mineral Nutrients from the Soil

The 16 chemical elements that are essential to plant growth can be divided into two main groups, nonmineral and mineral.

Transparency No. 1

A. Nonmineral - from air and water
The three nonmineral elements essential for plant growth are carbon (C), hydrogen (H), and oxygen (O). Carbon dioxide (CO_2) and water (H_2O) are the sources of these elements which are utilized in the photosynthesis process. A lack of sufficient carbon dioxide, water, or light will result in reduced growth but no distinct leaf symptoms.

B. Mineral - from the soil
The normal growth processes of plants involve absorption of mineral nutrients from the soil. The thirteen mineral nutrients are further divided into three groups - primary, secondary, and micronutrients.

1. Primary nutrients - Nitrogen (N), phosporus (P), and potassium (K) are used in relatively large amounts by plants, and therefore are usually the first minerals to become deficient in soils.
2. Secondary nutrients - Calcium (Ca), magnesium (Mg), and sulfur (S) are deficient in soils less often than the primary mineral nutrients; however, the term "secondary" does not define the amounts of Ca, Mg, and S required for plant growth.
3. Micronutrients - Manganese (Mn), iron (Fe), zinc (Zn), copper (Cu), boron (B), molybdenum (Mo), and chlorine (Cl) are removed from soils in much smaller amounts than the primary and secondary nutrients. For this reason they are referred to as micronutrients or "minor" or "trace" mineral nutrients.

III. Basic Nutrients and Their Relatioship to the Soil

A. Nitrogen

Nitrogen in its pure state is an odorless, tasteless, colorless, and inert gas. Nitrogen is always abundant in the atmosphere, as it constitutes about 80 percent of the air around us, yet nitrogen is one of the most critical elements for plant growth. The reason is that plants cannot utilize nitrogen as a gas; it must be combined with other elements into some stable form.

Plants absorb nitrogen when it is properly combined with hydrogen or oxygen. These combined forms are ammonium nitrogen (NH_4) or nitrate (NO_3). In the nitrate form, nitrogen is very quickly available to plants, but it is subject to movement in the soil and to loss by leaching. In the ammonium form, it is not so quicky available to plants, as it is more tightly held by the soil particles Most plants grow best when both forms of nitrogen are available in the soil.

The amount of nitrogen in a soil is directly related to to the amount of organic matter in the soil. Organic matter is the storehouse for nitrogen, and it is found largely in the topsoil or plow layer. Since soil organic matter is approximately five percent nitrogen, it follows that -- percent N x 20 = percent organic matter. Variation in the amount of organic matter generally parallels total nitrogen in the soil.

Transparency No. 2

Most of the soils in areas of high temperatures and humid conditions are low in nitrogen because of the rapid decay of organic matter and leaching. Also, cultivation hastens

the loss of organic materials and lowers the nitrogen content of the soil.

B. Phosphorus

In its pure form, phosphorus is a potentially harmful substance that will burst into flames when exposed to air. Before it can be used as a fertilizer, phosphate must be combined with another element, usually calcium or sulfur. Phosphorus in fertilizers is provided in the form of phosphoric oxide (P_2O_5).

This country is fortunate in having nearly one-third of the known supply of phosphorus in the form of rock phosphate deposits. However, native soil phosphorus in most cases is "bound" or "fixed" in very nonsoluble forms, so that only a very small part of the total supply becomes available in a growing season. For this reason, even soils with a high phosphorus content often fail to provide available supplies adequate for maximum plant growth and production. Most of our soils are low in available phosphorus, and the addition of phosphate will be necessary to get profitable crop yields.

Phosphorus materials in soils that are nearly neutral will be readily available to the crops. The most desirable pH range for phosphorus availability is about 6.0 - 7.5.

C. Potassium

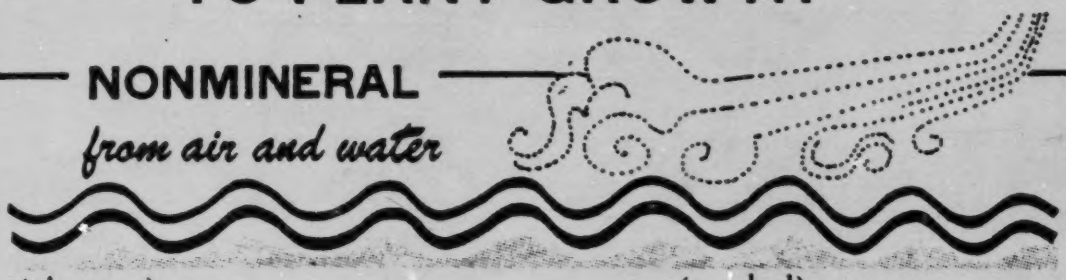
In a pure form, potassium is a highly caustic and dangerous chemical. It must be combined with other elements before it is usable as plant food in fertilizers. In fertilizers, potassium is guaranteed as potash (K_2O).

Our soil are generally far richer in potash than in nitrogen or phosphorus. Unfortunately, most of the potash is locked up in the soil in forms that plants cannot readily use.

CHEMICAL ELEMENTS ESSENTIAL TO PLANT GROWTH

NONMINERAL

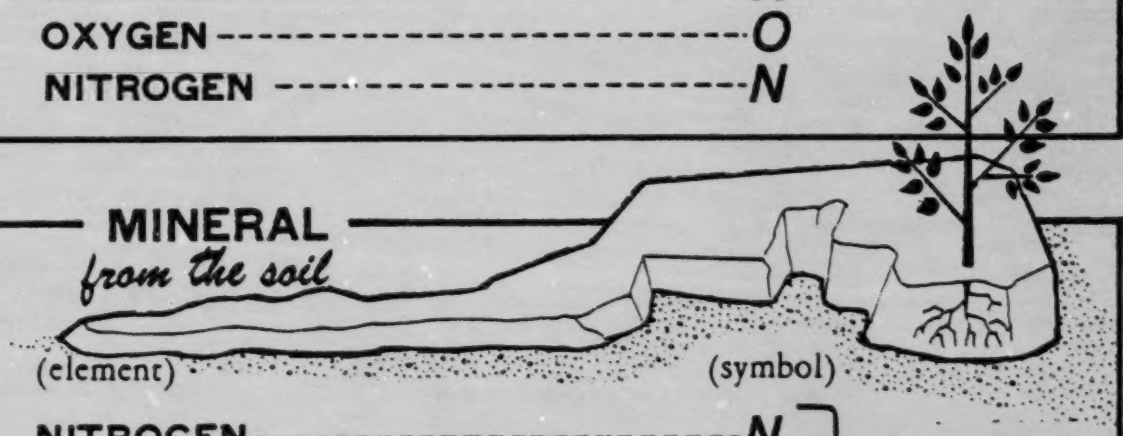
from air and water



(element)	(symbol)
CARBON	C
HYDROGEN	H
OXYGEN	O
NITROGEN	N

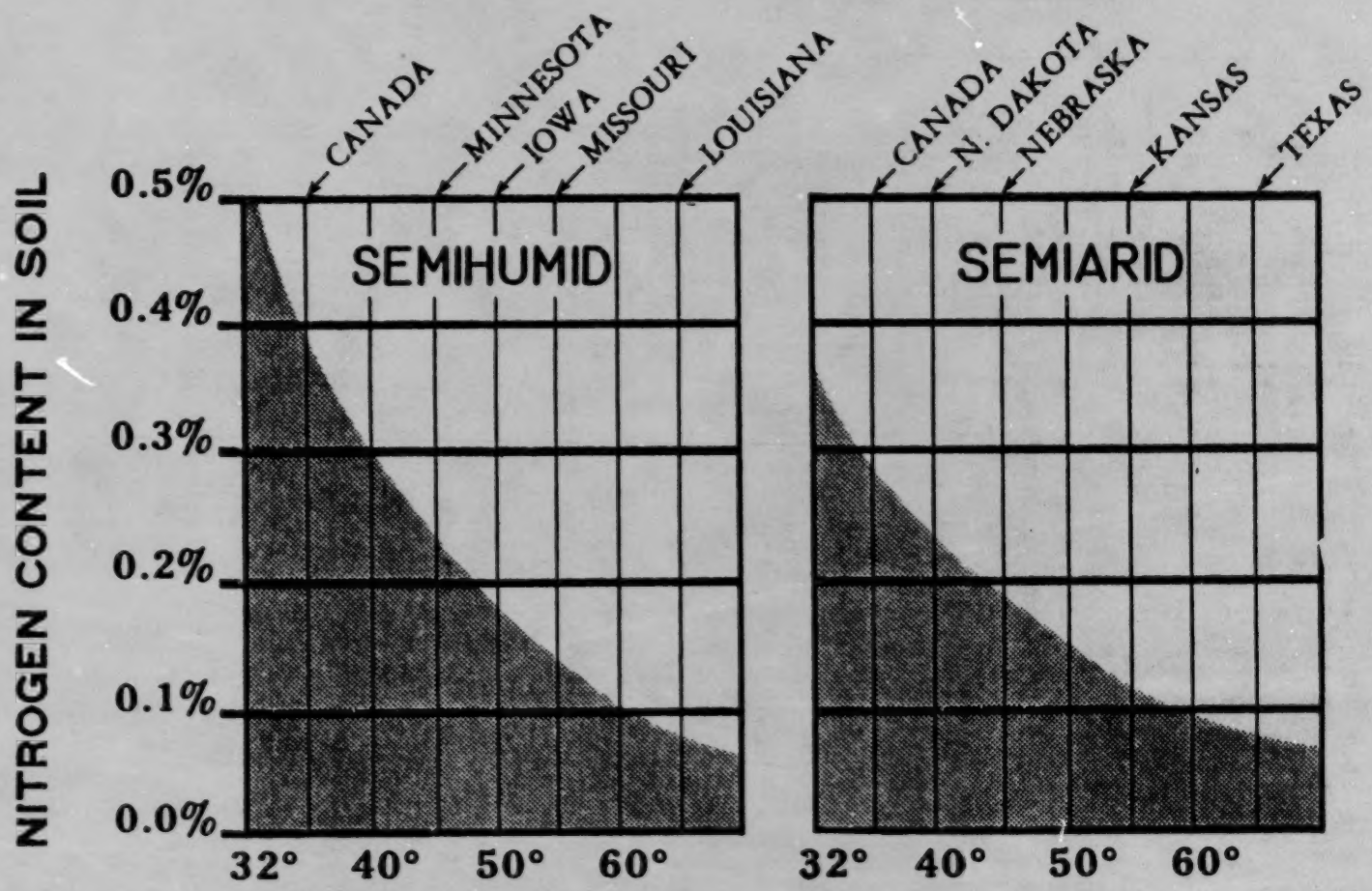
MINERAL

from the soil



(element)	(symbol)	
NITROGEN	N	PRIMARY NUTRIENTS
PHOSPHORUS	P	
POTASSIUM	K	
CALCIUM	Ca	SECONDARY NUTRIENTS
MAGNESIUM	Mg	
SULFUR	S	
IRON	Fe	MICRO-NUTRIENTS
BORON	B	
MANGANESE	Mn	
COPPER	Cu	
ZINC	Zn	
MOLYBDENUM	Mo	
CHLORINE	Cl	

NITROGEN CONTENT IN SOILS AS RELATED TO MEAN ANNUAL TEMPERATURE



Soil Science

Topic 7: Secondary Nutrients, Micronutrients, and Soil pH

Only in the recent years has attention been given to the importance of the secondary and micronutrients in soils. It was thought that most of our soils contained sufficient natural supplies of these elements, since they were required by plants in smaller quantities. Also, commercial fertilizers supplied considerable quantities of these elements as impurities and carriers of the primary nutrients.

Now that more highly refined materials are being developed to supply the nitrogen, phosphorus, and potassium, the supplies of secondary and micronutrients have been reduced. Today, with more intensive cropping, greater emphasis on higher yeilds per acre, and with the soil becoming more depleted, the need for all essential elements has become more pronounced. Also, it is known that reduced yields are often due to deficiencies of one or more of the secondary nutrients and micronutrients.

I. Secondary Nutrients and Their Relationship to the Soil

Calcium, magnesium, and sulfur are considered secondary elements because they are required in lesser amounts than the primary or major elements. However, it is necessary that they are present in the soil in the proper amounts.

A. Calcium (Ca)

Soils in the United States may average one percent calcium. Calcium is an essential element for plant growth; and it also plays an important role in other functions of the soil, especially as it relates to the acidity or alkalinity of soil. Most of the reserve calcium in the soil is in the form of calcium carbonate (limestone). When discussing soil elements, a person usually thinks of calcium and lime as having the same meaning.

Most sandy soils are deficient in calcium for two reasons:

1. The parent materials are low in calcium.
2. Lime is leached out of the upper layers of the soil.

There is less activity of the soil micro-organisms in calcium deficient soils; this slows the conversion of heavy mineral compounds into forms that can be used by plants. Most of the mineral elements are available to plants under near neutral conditions. Too much calcium can cause problems just as serious as when too little calcium is present. Calcium deficiency is corrected by the addition of lime. This will be discussed in more detail in a study of soil acidity and alkalinity. Clay and clay-type soils usually have sufficient calcium for crop production. The reason for this is that the limestone and parent materials are usually high in calcium content.

B. Magnesium (Mg)

Magnesium is another essential plant food element that comes directly from the soil. The amount of magnesium in the soil varies greatly. The total amount ranges from as little as 0.05% to as much as 1.93%. In general, leached sandy soils will be low in magnesium. Calcium and magnesium are very closely related in that they have similar chemical reactions in soil solutions; therefore, magnesium is usually deficient in soils that are low in calcium (acid soils).

The ratio of calcium to magnesium is important. If there is too much calcium in proportion to magnesium, crops will show a deficiency of magnesium.

It has been demonstrated that magnesium aids in the uptake of phosphorus. This fact is of particular interest to the livestock producer, because forage plants grown in magnesium deficient areas may have inadequate amounts of phosphorus for satisfactory animal nutrition.

Reserve magnesium occurs mostly in dolomitic limestone, a rock that consists of a mixture of calcium and magnesium corbonate.

C. Sulfur (S)

A typical soil contains a small amount of sulfur, averaging about 0.15 percent. A large part of the sulfur that plants use comes from the soil through biological release from decomposing organic matter or from sulfates in fertilizer applied to the soil.

Sulfur is important in the study of soils, because it is required by plants to manufacture certain essential proteins. Sulfur is also required for the synthesis of certain vitamins in plants.

Sulfur for plant food is available from several sources.

1. Natural sulfur - Mineral rocks contain sulfur in the form of iron sulfide (FeSo). As these rocks break down, available sulfur in the form of sulfates becomes available to plants. Organic matter also contains sulfur which is released as the organic matter is decomposed.

   Another way in which sulfur is returned to the soil by nature is from rainfall. Sulfur dioxide (So_2), a gas in the air, is carried to the soil by rainfall. The amount of sulfur in rainwater will depend on how much sulfur dioxide is given off in the manufacturing process. Considerable sulfur is liberated into the atmosphere in the burning of coal. In some industrial areas so much sulfur dioxide is produced that sulfur binds up to levels that may be harmful to plant and animal life. Too much sulfur may be as much a problem as too little. A proper balance with other elements is necessary.

2. Commercial fertilizers - In sulfur deficient areas much of the sulfur that plants use must come from fertilizer materials such as gypsum (Ca So_4), super phosphate [$Ca(HPO_4)$], ammonium sulfate [$(NH_4)_2SO_4$], and potassium sulfate (K_2SO_4).

II. Micronutrients and Their Relationship to the Soil

The micronutrients (iron, boron, manganese, copper, zinc, molybdenum, and chlorine), also referred to as minor or trace elements, are required by plants in very small quantities. However, all of these elements are necessary for plant growth. Unsatisfactory plant growth in many areas, especially on sandy or muck soils, is traceable to the lack of one or more of the micronutrients.

A. Iron (Fe)

There is an abundance of iron in nearly all soils; however, the available iron in some soils may be so low that plants are unable to absorb enough for normal development. Lack of iron causes chlorosis, or a whitening or yellowing of the leaves of plants.

B. Boron (B)

Deficiencies of boron have been reported in 21 states with many different crops being affected. Additional boron may be added to the soil as borax in fertilizers. On the other hand, excess quantities of boron in the soil may be injurious to plants. Too much boron may be accumulated in soils from irrigation water.

C. Manganese (Mn)

Deficiencies of manganese have been reported in 25 states. Manganese appears to function in the sythesis of chlorophyll, since a lack of it causes discoloration of plant leaves.

D. Copper (Cu)

Copper is generally deficient in peat and muck soils.

Soils high in organic matter, particularly newly cultivated peat soils, are those most frequently having a copper deficiency.

When soils are low in copper it is usually supplied by copper sulfate.

E. Zinc (Zn)

Deficiencies of zinc have been reported in 30 states. Zinc sulfate is usually applied in a fertilizer when additional zinc is needed.

F. Molybdenum (Mo)

Instances of molybdeum deficiency are very few, as it is needed in such small amounts. Applications of as little as one ounce of molybdenum oxide per acre may be adequate

to supply sufficient molybdenum for normal plant growth. Some soils have a natural excess of molybdenum which is toxic to livestock.

G. Chlorine (Cl)

All authorities do not consider chlorine as a necessary nutrient for all higher crops. They do agree that if chlorine is essential, only small amounts are needed. In commercial agricultural production, a deficiency of chlorine is no problem; under certain conditions excesses may be a problem.

III. Soil pH

A. What soil pH means

The most important single chemical characteristic of a soil is the degree of acidity or alkalinity. Soil scientists refer to soil acidity and alkalinity as soil reaction.

1. Soil acidity and alkalinity - To understand the chemical nature of acidity and alkalinity it is necessary to understand the ion exchange of soil particles.

Transparency No. 1

Water and dissolved plant nutrients in the form of ions are the principal constituents of a soil solution. In a neutral solution, there is a balance between the number of positive H= (hydrogen) ions called cations and negative OH^- (hydroxyl) ions called anions. For example, when a water molecule ionizes, it forms on H^+ and one OH^- ion, according to the chemical formula: $H_2O(H^+)\ (OH^-)$.

Transparency No. 2

In the soil solution, as either soil solids or salts are dissolved in the water, additional H^+ or OH^- ions become a part of the solution.

Figure 1: The ion exchange occurs as the mineral nutrients held in the soil solution are absorbed by plant roots feeding in the soil. In the nutrition absorption exchange, the positively charged cations, Ca^{++} (calcium), Mg^{++} (magnesium), K^+ (potassium), NH_4+ (ammonium), Cu^{++} (copper), Mn^{++} (manganese), Zn++ (zinc), and Fe^{++} (iron) may be exchanged for H^+ ions. Conversely, the negatively charged nutrient aions NO_3- (nitrate), Cl^- (chlorine), SO_4^{--} (sulfate), and H_2PO_4- (phosphate) may be absorbed in exchange for OH^- or basic ions.

Figure 2: When a soil solution contains more acid forming elements (H^+ ions) than alkaline or basic elements (Ca^{++}, Mg^{++}, K^+, H_2PO_4-, etc.) the soil will test acid.

Figure 3: If the soil solution contains more basic elements than acid forming elements the soil will test alkaline.

2. Soil reaction - Soil reaction is expressed in pH values, In the symbol pH, the "p" refers to pressure, and the "H" refers to hydrogen ions. Thus, "pH" refers to the pressure or concentrations of hydrogen ions.

   Soil reaction can be determined only by a soil test. A laboratory test with a pH meter gives most accurate results. Soil test kits containing color indicators can be used, but are less accurate. The result of the soil test is read on a pH scale. Transparency No. 5 illustrates the pH scale for soil reactions.

Transparency No. 3

The pH scale is similar to a rule or a thermometer with a range of 0-14 which represents the amount of acidity or alkalinity in soil solutions.

Note that pH 7 is the neutral point, neither acid nor alkaline. The acid region is below pH 7 with the amount of acidity increasing as you move down the scale. The alkaline region is above pH 7 with the amount of alkalinity increasing as you move up the scale.

To further illustrate pH values, several familiar products are listed to the right of the scale showing their approximate degree of acidity or alkalinity as rated on the pH scale.

Transparency No. 4

In taking readings from the pH scale, it is important that the relative strength changes 10-fold for each unit change in pH. For example, a pH value of 6.0 is ten times more acid than a pH of 7.0, similarly, a pH value of 8.0 is 10 times more alkaline than a pH of 7.0. If the pH value is 5.0 it is 100 times more acid than a pH of 7.0 likewise, a pH value of 9.0 is 100 times more alkaline than a pH of 7.0, and etc.

To further illustrate, look back at Transparency No. 3. Cow's milk is slightly acid, fresh beans are moderately acid, tomatoes are strongly acid, and lemons are extremely acid. Applied to the pH scale this would indicate that fresh beans are approximately 10 times more acid than cow's milk, while tomatoes are more than 100 times more acid than cow's milk, and lemons are more than 10,000 times more acid than cow's milk. A similar comparison could be made on the alkaline range on the scale.

Transparency No. 5

Most soils have a pH range btween 5 and 8 under field conditions. However, a few soils will have lower or higher pH values. In general, most plants are best suited to a pH of 5.5 on organic soil and a pH of 6.5 on mineral soils. Soils with extremely low or extremely high pH values are not productive without special treatment.

Remember, soils that are acid will have varying amounts of

hydrogen which is not a plant nutrient (the plant gets its hydrogen from the air); and soils that are alkaline will contain considerable amounts of calcium, magnesium, and potassium, which are soil plant nutrients. The pH scale, then, is an indicator of acidity, alkalinity, or neutrality of soils from a chemical standpoint.

B. How soil pH affects availability of plant nutrients. Chemical reactions take place between plant nutrients and the soil. This reaction affects the availability of nitrogen, phosporus, potash, calcium, magnesium, and other plant nutrients or minerals. Transparency No. 6 gives the plant nutrients at different pH levels.

Transparency No. 6

The availability of most plant nutrients is directly or indirectly affected by soil pH.

1. Nitrogen - Although nitrogen is generally available over a wide range in pH, the rate of organic matter decomposition, nitrification, and other reactions involving nitrogen transformation in soils decreases under extreme acidity or alkalinity. Nitrogen availability is highest in soils with a pH between 6.0 and 8.0.
2. Phosphorus - The availability of phosphorus is influenced greatly by soil pH. In acid soils with a pH below 5.5 or highly alkaline soils with a pH above 8.3, the soil phosphorus may be converted to less available phosphate forms. Greatest phosphorus availability is between 6.5 and 7.5.
3. Potassium - Calcium - Magnesium - Sulfur - The soil pH has a limited effect on the availability of these nutrients, especially above a pH value of 6.0.
4. Iron - Maganese - Boron - Copper - Zinc - Few deficiencies exist where the pH is below 7.5.
5. Molybdenum - Soil pH affects the chemical form and availability. As the pH increases above 6.5 molbdenum becomes more available.

A pH value within these ranges does not necessarily mean that there is sufficient supply of these elements. This means, as far as soil reaction is concerned, that conditions are favorable to plants if the element is present in sufficient quantity for plant production.

C. What affects pH of a soil
   1. Materials from which soils are formed: Limestone forms soils with high pH's. Sandstone, kaoline, and silica form acid soils.
   2. Amount of rainfall
      High rainfall causes the basic elements to "leach out" or to be washed down or out of the soil leaving the soil with a more acid reaction (lower pH).
   3. Erosion
      Soil erosion reduces the amount of calcium and magnesium in the soil by reducing the amount of topsoil where they are located.

4. Removal of calcium and magnesium by crops
As the base nutrients are used by plants, they are replaced by acid forming hydrogen.

5. Organic matter content
Other things being equal, the higher the organic matter content, the lower the pH value (Organic acids form as decomposition takes place).

6. Use of certain types of fertilizers
Some commercial fertilizers leave acid residues. This does not mean that these fertilizers should not be used on acid soils. There are other things to be considered when selecting fertilizer materials.

D. How soil pH affects plant growth
Different kinds of plants have the ability to grow and produce on soils with different soils in pH values. Some grow only in acid soils, while most crop plants do best on moderately to slightly acid soils. Other plants grow better on slightly alkaline soils.

Transparency No. 7

Soil pH should be considered when selecting types of plants best fitted to a particular soil.

E. How pH value of a soil may be corrected

1. Reducing soil acidity
Reducing acidity and increasing the pH involves removing or inactivating hydrogen and aluminum within the soil system.

Acid or "sour" soils may be neutralized or "sweetened" by the addition of lime to the soil. Lime contains calcium and magnesium which replaces hydrogen and aluminum. A number of materials can be classified as liming materials; however, ground agricultural limestone ($CaCo_3$) and ground dolomitic limestone ($CaCo_3$+35 to 40% Mg CO_3) are the most commonly used materials for commercial crop production purposes. Dolomitic lime does not react as rapidly as agricultural lime and therefore stays in the soil for a longer period of time.

The amount of lime required and the frequency of applying lime will depend on several factors. These are:

a. Crops to be planted - Different crops require different pH levels.
b. Soil type - Fine-textured soils contain more clay and require more lime to bring about the pH change than is needed for coarse-textured soils.
c. Organic matter content - Soil reaction occurs faster in soils with high organic matter content.

d. Neutralizing value of liming materials - Some materials have a greater capacity to neutralize acidity faster.

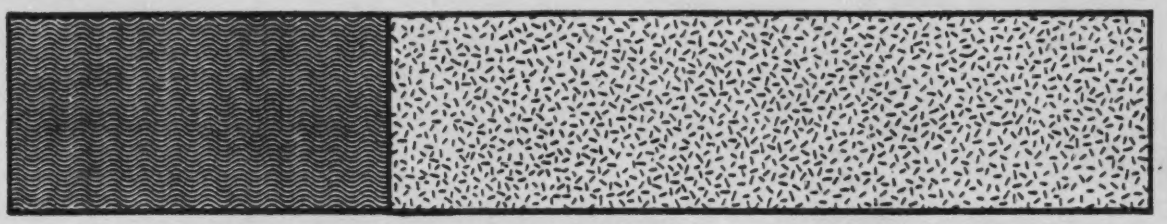
The rate at which lime reacts in a soil is dependent upon the kind of liming material, the size of the particles, the degree of mixing with the soil, and the initial pH. Most liming materials, especially ground limestone, are slowly soluble in water and must be in contact with soil particles or acids to change the pH. A liming material composed of small particles will react more quickly than a coarse material. A given amount of lime usually causes less pH change in strongly acid soils, because of the higher amount of acidity represented by a pH unit (see Transparency No. 4).

2. In alkali soils, the exchangeable sodium (Na) makes the soil almost impervious to water. To reduce alkalinity, the sodium must be replaced by another cation and then leached downward out of the reach of plant roots. Calcium is often used to replace sodium in alkali soils. Calcium sulfate (gypsum) is considered the best source.

Alkaline soils can also be reclained by the use of acid - forming fertilizer materials leaving an acid residue in the soil are anhydrous ammonia, ammonium sulfate, ammonium nitrate, and urea. Sulfur, which readily oxidizes to sulfuric acid, is used extensively in the manufacture of fertilizer materials. The amount of fertilizer material and the frequency of application for reducing soil alkalinity would be affected by the same factors as stated for reducing soil acidity.

Soil testing is the practical and scientific way to determine pH. A pH reading and a lime or gypsum recommendation will accompany the fertilizer recommendation you receive from your OSU extension agent when you have a soil test done.

BASIC CONSTITUENTS OF A SOIL SOLUTION

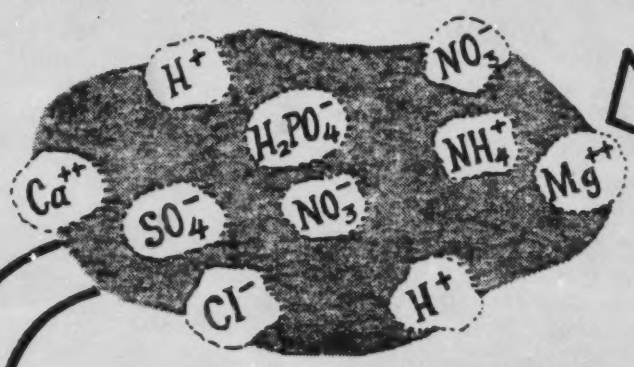


WATER *plus* DISSOLVED PLANT NUTRIENTS

or

H_2O + $(H^+)(OH^-)$ IONS

A NEUTRAL SOIL SOLUTION



EQUAL NUMBER OF

ACID FORMING (H^+) IONS

and

HYDROXYL (OH^-) IONS (basic)

ION EXCHANGE OF SOIL PARTICLES

FIGURE 1 :

◆ Mineral nutrients held on the surface of a soil particle are absorbed ⇨

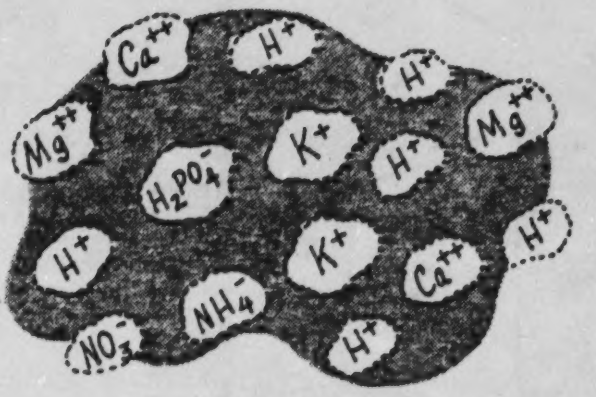


FIGURE 2 :

◆ A soil particle with mostly hydrogen ions tests ACID ⇨

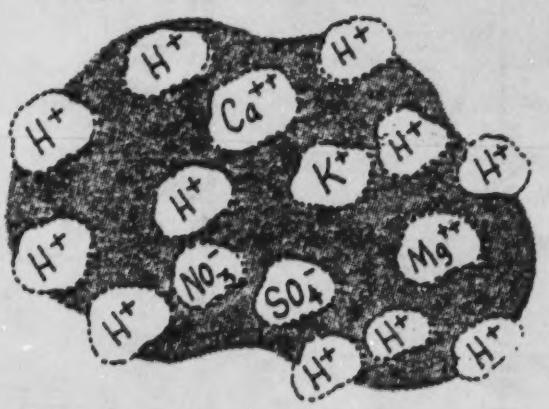
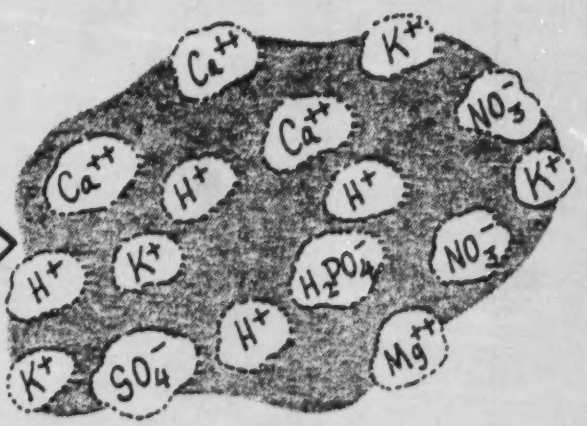
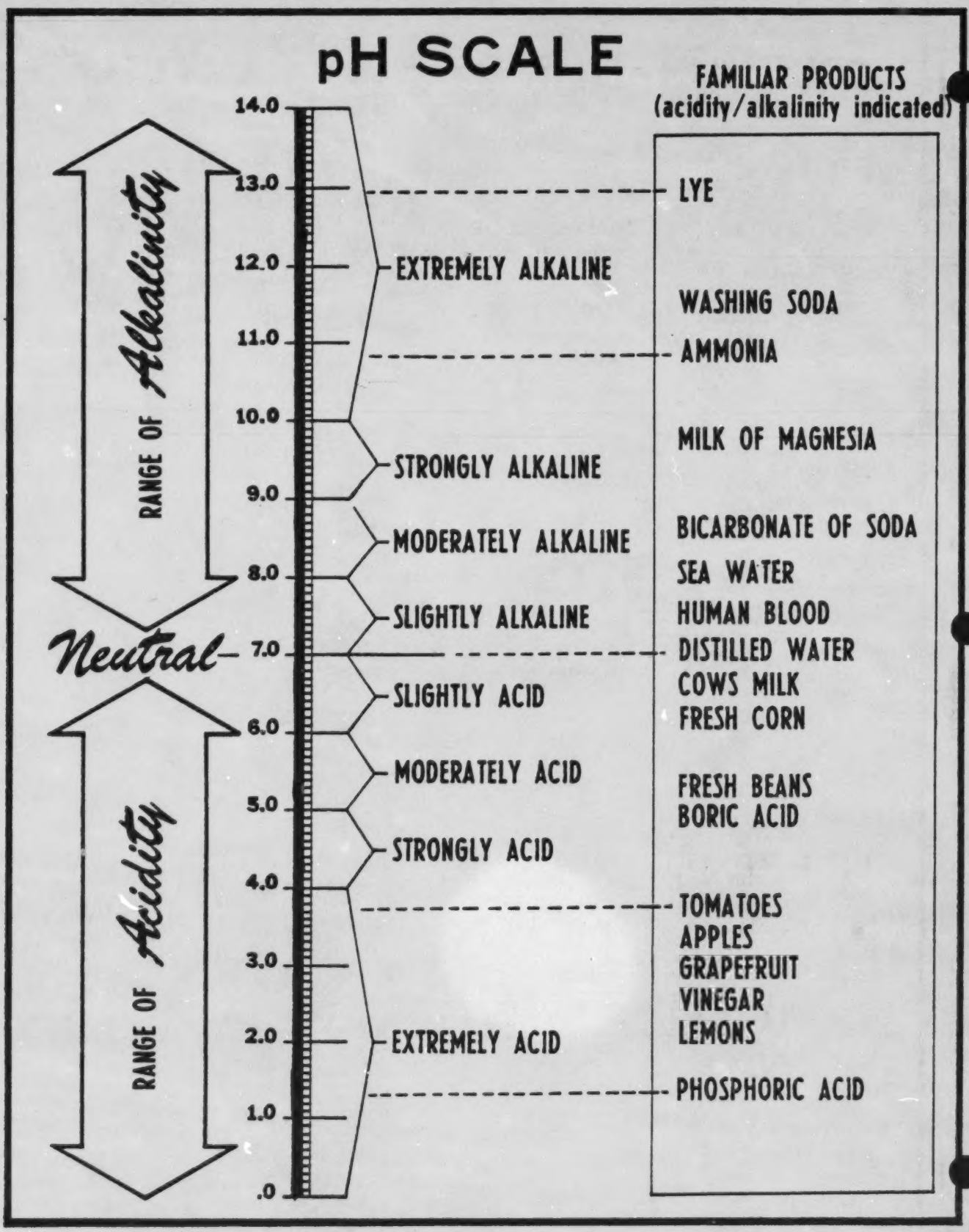
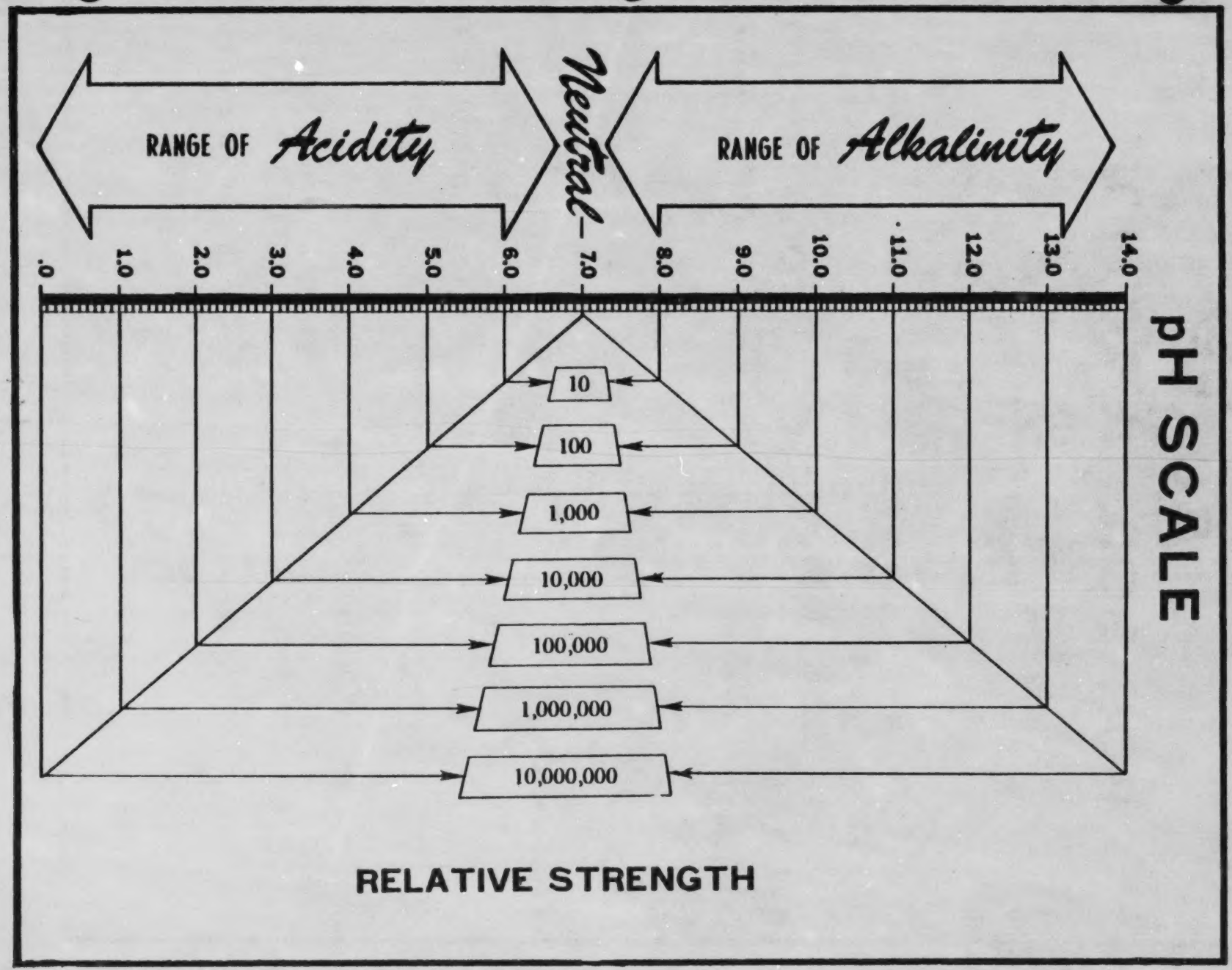


FIGURE 3 :

◆ A soil particle with mostly basic ions tests ALKALINE ⇨

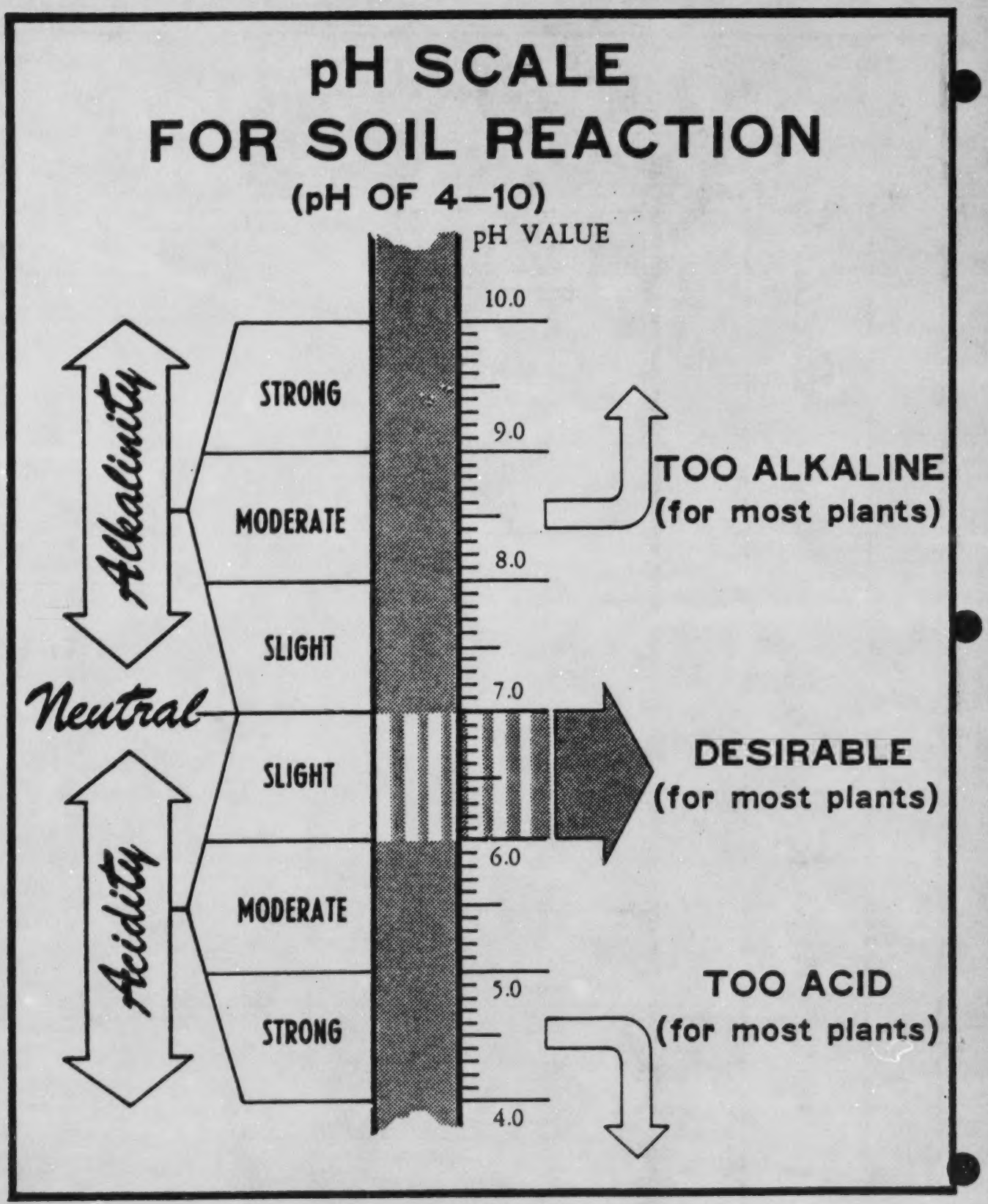



pH SCALE
FAMILIAR PRODUCTS
(acidity/alkalinity indicated)
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
.0
RANGE OF Alkalinity
Neutral
RANGE OF Acidity
EXTREMELY ALKALINE
STRONGLY ALKALINE
MODERATELY ALKALINE
SLIGHTLY ALKALINE
SLIGHTLY ACID
MODERATELY ACID
STRONGLY ACID
EXTREMELY ACID
LYE
WASHING SODA
AMMONIA
MILK OF MAGNESIA
BICARBONATE OF SODA
SEA WATER
HUMAN BLOOD
DISTILLED WATER
COWS MILK
FRESH CORN
FRESH BEANS
BORIC ACID
TOMATOES
APPLES
GRAPEFRUIT
VINEGAR
LEMONS
PHOSPHORIC ACID



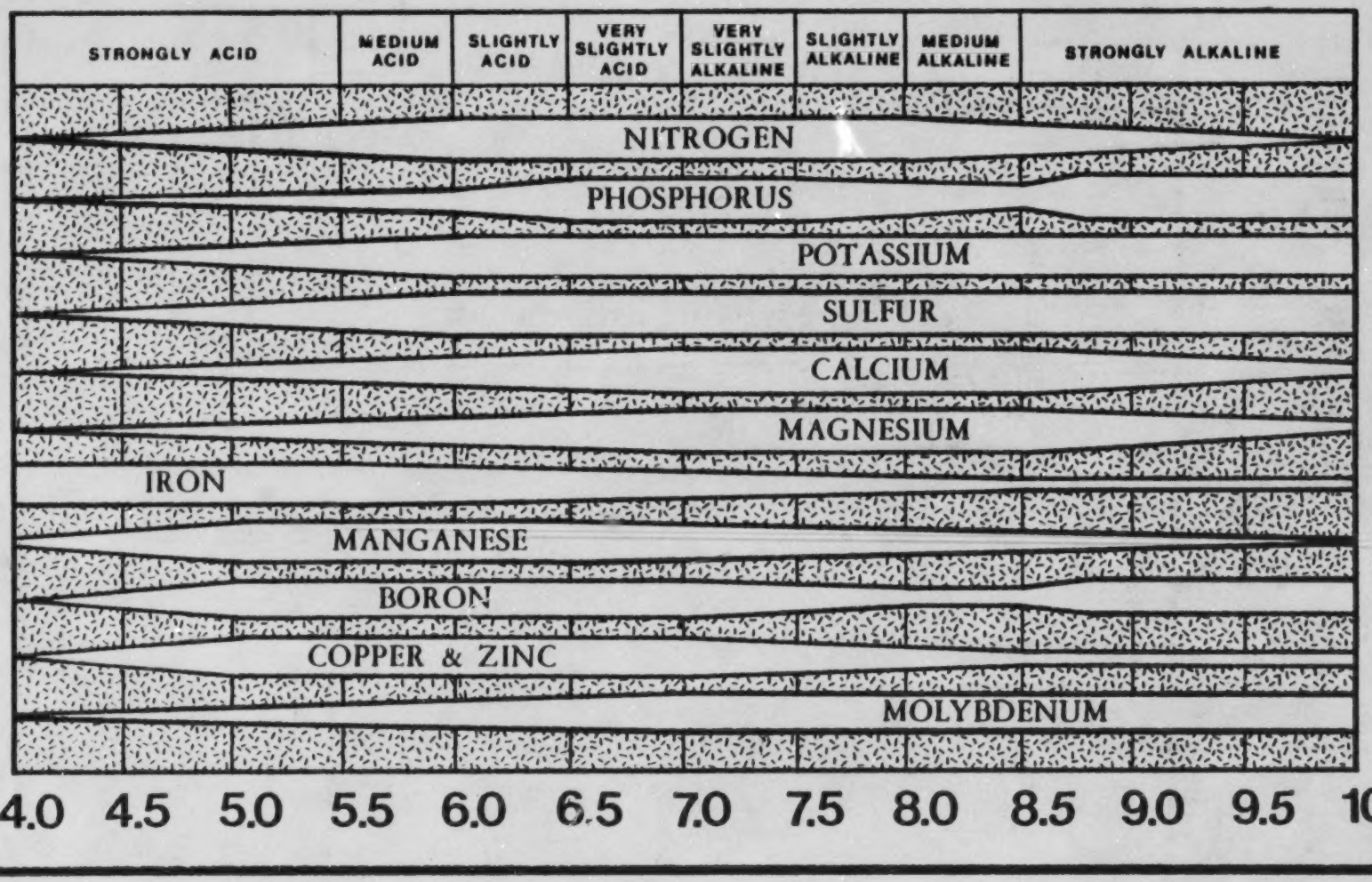
TM - 4

Ag II - IV - 69

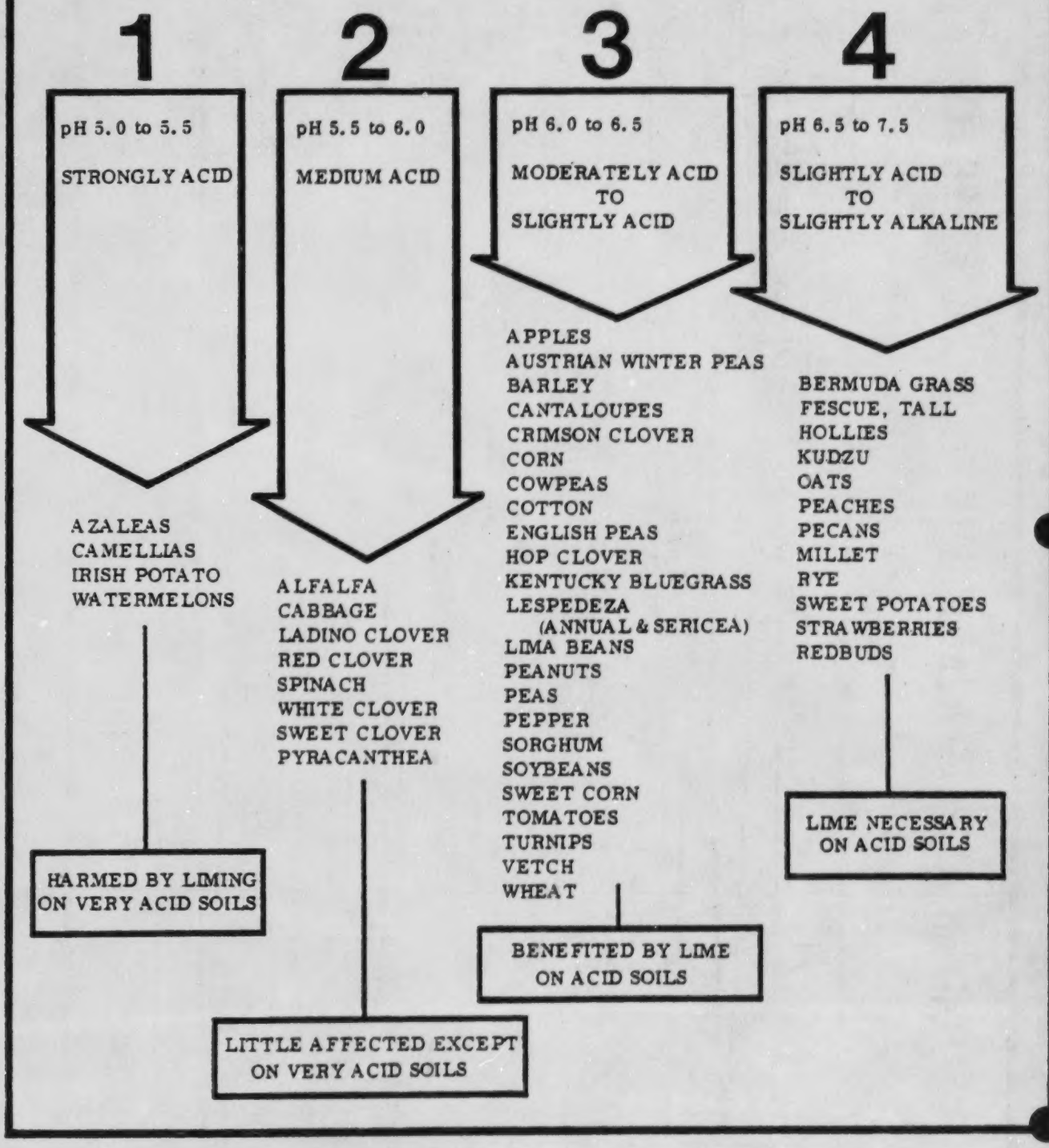

pH SCALE
FOR SOIL REACTION
(pH OF 4—10)
pH VALUE
10.0
9.0
8.0
7.0
6.0
5.0
4.0
Alkalinity
STRONG
MODERATE
SLIGHT
Neutral
SLIGHT
MODERATE
STRONG
Acidity
TOO ALKALINE
(for most plants)
DESIRABLE
(for most plants)
TOO ACID
(for most plants)

SOIL pH AFFECTS AVAILABILITY OF PLANT NUTRIENTS

NOTE: AVAILABILITY OF NUTRIENTS TO PLANTS DECREASES AS WIDTH OF LINE DECREASES.



SOIL pH RANGE MOST SUITABLE FOR VARIOUS PLANTS



Soil Science

Topic 8: Recognizing Soil Deficiencies

Suggested Procedure and Activities

1. Run a chemical soil test with a soil testing kit if available.
2. Run tissue tests on growing plants if testing kit is available.
3. Take a field trip to see growing plants that indicate soil deficiencies.

I. Background of Soil Deficiencies

There is an old folksong which says "we eat when we are hungry, we drink when we are dry, if we can't eat and drink, we will surely die." Calves bawl, pigs squeal, colts knicker, cats meow, and babies cry when they are hungry or thirsty. Plants are living and have some of the same problems as man and animals. Since they cannot make themselves heard, they send out silent signals. We have seen the signs or signals, but do we understand their meaning? If we study the primary, secondary, and micronutrients essential for plant growth in relation to the signals given when plants are deficient, we may be able to increase production and farm income.

II. Nutrient Functions and Deficiency Symptoms

Each of the soil nutrients is involved in one or more processes affecting plant growth. Therefore, symptoms resulting from a reduced level in these processes cause visual evidence of deficiency symptoms.

A. Primary Nutrients

1. Nitrogen (N)
   a. Function - Nitrogen is needed in the conversion of amino acids into protein. It gives dark green color to the leaves and hastens the growth of the plant. It also increases the protein content of the plant, thus increasing its nutritional value as a food product.
   b. Deficiency Symptoms - A light green leaf color is first noticed, followed by a yellowing of the older leaves, starting at the tip. Plant growth is slow, and production is reduced. Nitrogen deficiency is most often observed on non-legume crops.
2. Phosphorus (P)
   a. Function - Phosphorus is essential in plant metabalism for the utilization of energy. It must be present in every plant cell before cell division can occur. Available phosphorus in the soil favors rapid plant growth and development and hastens fruiting and maturity.
   b. Deficiency Symptoms - Slow growth of small, slender stalks and delayed maturity are noticeable symptoms.

Also plant leaves remain small, and they exhibit a purple discoloration, especially on young plants. A phosphorus deficiency interferes with the normal opening of the stomata of certain plants, and seed development is hindered, thus reducing plant yields.

3. Potassium (K)

a. Function - Potassium is associated with the water relationship in plants. It serves as a regulator for metabalism and growth reactions. Potassium also helps the plant resist disease, cold weather, and other adverse conditions.

b. Deficiency Symptoms - Leaf tips and margins dry up and, under extreme deficiency, the entire leaf turns brown and dies. Older leaves are affected first. On alfalfa and clover white dots appear near the leaf margin when potassium is deficient. Reductions in yield and quality of fruit and seeds are also signs of deficiency.

B. Secondary Nutrients

1. Calcium (Ca)

a. Function - Calcium a constituent of the cell wall is needed in large quantities for cell elongation and division. Rapidly growing root tips are high in calcium.

b. Deficiency Symptoms - Younger leaf tips may remain folded and become gelatinous in appearance, but deficiency symptoms are seldom seen under field conditions because of secondary effects such as high acidity. Poor root growth and roots turning black and rotting are other indications of calcium deficiency.

2. Magnesium (Mg)

a. Function - Magnesium is the key plant food element in chlorophyll, the green coloring matter in plants which is necessary for amino acid production. It also affects the viability of seeds.

b. Deficiency Symptoms - The leaves exhibit a chlorotic condition (yellowing). In corn leaves turn a reddish color with green veins. Potatoes and cabbage leaves turn an orange-yellow color. Symptoms appear first in older leaves, and the loss of color proceeds from the base upward.

3. Sulfur (S)

a. Function - Sulfur is needed in the formation of plant cells and in chlorophyll. It is an essential component in the amino acid production of plants.

b. Deficiency Symptoms - Loss of green in leaves and veins may be associated with nitrogen deficiency. Leaves get smaller and stems are thin and woody. Death may result in the seedling stage, otherwise plants appear to be stunted.

C. Micronutrients:

1. Boron (B)
   a. Function - Boron is essential for pollen, seed, and cell wall formation.
   b. Deficiency Symptoms - Plant growth is stunted and leaf tips begin dying, with the young leaves being affected first. Alfalfa is particularly sensitive and leaf tips exhibit a reddish-yellow discoloration. Symptoms may vary with other plants. For example, brown-heart in beets and water core in cabbage and cauliflower, while apples develop corky spots.

2. Manganese (Mn)
   a. Function - Manganese activates enzymes involved in chlorophyll formation.
   b. Deficiency Symptoms - A loss of color in young leaves is the first indicator, with a yellowing between veins and brownish-black spots appearing. The entire plant may appear stunted. In small grains, grayish areas appear near the base of younger leaves.

3. Copper (Cu)
   a. Function - Copper is necessary for forming blood hemoglobin in animal metabolism.
   b. Deficiency Symptoms - The upper leaves of plants wilt badly and plant growth is reduced in proportion to the degree of shortage. During the flowering stage, the amount of seed that is set is greatly reduced.

4. Zinc (Zn)
   a. Function - Small amounts are essential to plant growth and development.
   b. Deficiency Symptoms - The need of zinc is indicated by small, yellow mottled leaves in fruit trees.

5. Iron (Fe)
   a. Function -Iron is a catalyst in the formation of chlorophyll and acts as an oxygen carrier within the plant.
   b. Deficiency Symptoms - Plants starving for iron exhibit a chlorosis - a failure to form chlorophyll. Plants showing a slight deficiency exhibit a pale green color with a sharp distinction between green veins and a yellowish leaf tissue. Under severe deficiency, the entire plant turns yellow-to-bleached white.

6. Chlorine (Cl)
   a. Function - Little is known about the exact role of chlorine except that it is essential for plant growth.
   b. Deficiency Symptoms - Only artificially induced deficiencies have been observed.

7. Cobalt (Co)
   a. Function - Cobalt is needed in very small amounts for nitrogen fixation by legumes.
   b. Deficiency Symptoms - About the only observable cobalt deficiency is noticed in animals that are feeding on forages that are deficient.
8. Molybdenum (Mb)
   a. Function - Molybdenum activates the enzyme which reduces nitrates to ammonium in plants. It is also essential for nodule formation by legumes.
   b. Deficiency Symptoms - Plants having a deficiency are stunted and pale yellow in color. Grain crops are yellow-green, usually being more pronounced in the younger leaves. On citrus plants, leaves develop water soaked areas called "yellow spots."

III. Symptoms of Soil Nutrient Deficiencies in Selected Crops

Soil nutrient deficiency symptoms of some of the most common crops in Oregon are described below:

Crop	Deficiency Soil Nutrient	Symptoms
A. Corn	Nitrogen	1. Stunted and spindly in appearance. 2. Leaves are yellowish to orange-yellowish in color. 3. Tips of leaves may die. 4. A condition called "firing" frequently occurs. 5. "Firing" is a condition in which the tip as well as the entire leaf begins to dry and change color.
	Transparency No. 1	
	Phosphorus	1. Corn may have sufficient nitrogen and potash but be retarded in rate of growth. This slow maturi.y is due to the lack of phosphorus.
	Transparency No. 2	2. Plant may be spindly and dark green in color but become purplish in color.
	Potassium	1. The growth of the seedling and young plants in corn is slow.

Crop	Deficiency Soil Nutrient	Symptoms
	Transparency No. 3	2. The young leaves may show signs of yellowing. 3. A scorched appearance on the edge and tip of corn leaves is evident. 4. The size of ears produced on the plant is usually well below average. 5. The kernels are immature and easily accessible to ear-rot organisms.
	Magnesium	1. In severe cases a slight yellow streaking is visible between the parallel veins on the corn bones. 2. There may be yellowish-green and white streaks running the entire length of the leaves.
B. Small grains (Oats, barley, and wheat)		
	Nitrogen	1. Erect and spindly. 2. Stunted plants. 3. Yellowish leaves with purplish stems. 4. Leaves dry out from tip toward base.
	Phosphorus	1. Slow growth. 2. Lack of stooling.
	Potassium	1. Tips and edges of older leaves turn from green to yellow to brown-die (commonly called "edge scorch").
C. Legumes	Nitrogen	1. Slow growth. 2. Decreased branches of plant. 3. Small plants at maturity. 4. Symptoms may cause "chlorosis"-- a pale green color in plants.

Crop	Deficiency Soil Nutrient	Symptoms
	Phosphorus	1. Small and poorly developed plants. 2. Flowering and seed production may be slow developing. 3. Bluish-green color may appear on leaves.
	Potassium	1. Irregular yellow spots on edges of leaves. 2. Yellow spots turn brown and die--dead tissue falls out and leaf is ragged in appearance.
	Magnesium	1. Varies with species of legumes.
D. Truck Crops	Nitrogen	1. Slow growth. 2. Leaves change from green to yellowish color. 3. Stems may become hard and fibrous.
	Phosphorus	1. Slow growth and late maturity in vegetables. 2. Stems are slender and may be fibrous. 3. Leaves are small.
	Potassium	1. Bronzing on edges of leaves of most vegetables. 2. Other symptoms vary according to crop.
	Boron	1. Yellowing tip of leaves on tomatoes. 2. Yellowing tip is followed by orange appearance and death. 3. Celery stems crack. 4. Cabbage and cauliflower are affected by rotting of the stem.

The above deficiencies and symptoms are only a very basic view of the nutritive deficiencies that can be related to the soil by the observation of plants.

IV. Measuring Soil Deficiencies

Four general methods which may be used to determine the fertility level of a soil are as follows:

A. Field test plots
   1. Most reliable means of evaluating the natural fertility of a soil and its response to different treatments.
   2. Size of plots vary but usually 1/20 of an acre or less.
   3. Effects of climate and other environmental factors can be accounted for.
   4. Oregon State University conducts test plot tests at each of its branch stations throughout Oregon.

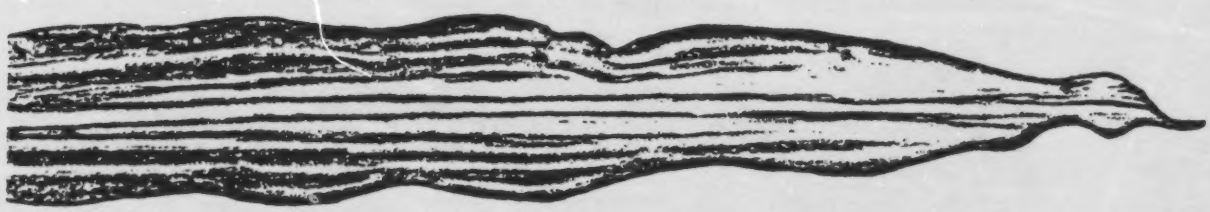
B. Pot tests
   1. Usually conducted in greenhouses under controlled conditions, but may be conducted out-of-doors.
   2. Earthenware pots, varying from 1 to 10 gallons in size, are one of the simplest forms used.
   3. The advantage of greenhouse experiments is that a large number of soils or treatments can be tested in a relatively short time.
   4. The disadvantage of greenhouse experiments is that controlled temperature and moisture conditions are much different from those in the field and the soil used is not in its normal condition.

C. Chemical soil tests
   1. Chemical soil tests are available which indicate total plant food resources; however, "quick tests" or "rapid soil tests" have been developed to determine usable plant food.
   2. Different soils respond differently to various tests.
   3. Purpose for which a test is made varies. Crop land, pasture land, and vegetable gardens are examples of soils with varying requirements.
   4. Soil tests are frequently used for making fertilizer recommendations.

D. Plant tissue tests
   1. Tests made on tissues of growing plants.
   2. Plants indicate the soil's ability to furnish plant foods.
   3. Disadvantage may be not all plants have same ability to gather elements from the soil. Also, tissue tests may be too late in the growing season for corrective measures to be used.
   4. Scientists agree that tissue tests are valuable in the diagnosis of plant food deficiencies.

NITROGEN deficiency in corn

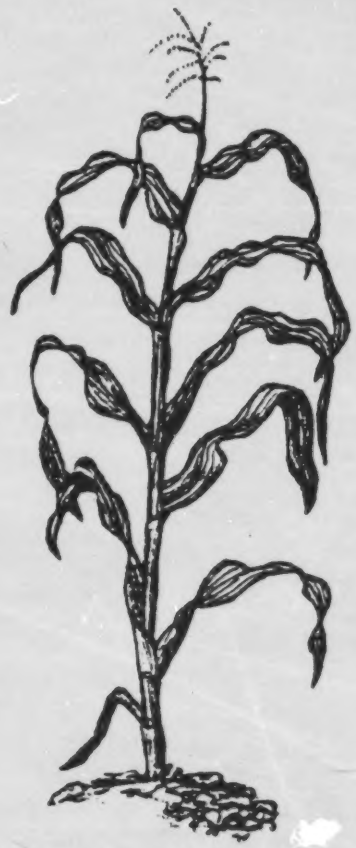
SMALL EARS AND LOW PROTEIN CONTENT
RESULT FROM N DEFICIENCY



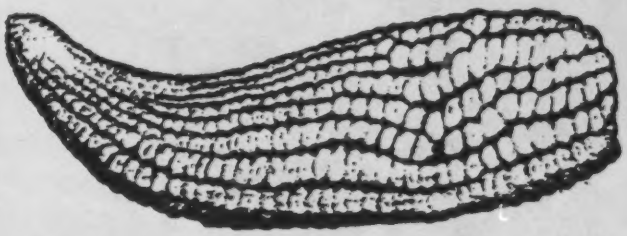
YELLOWING STARTS AT TIP AND MOVES
ALONG MIDDLE OF LEAF

PHOSPHATE deficiency in corn

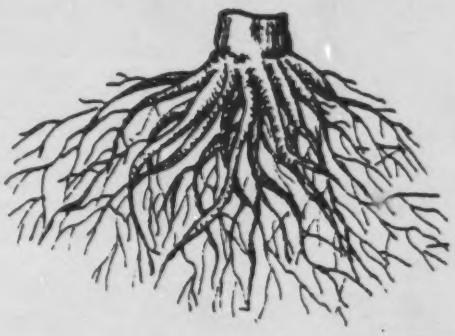
P SHORTAGE MARKS LEAVES WITH REDDISH-PURPLE COLOR



P CONTROLS STALK SIZE AND EAR SET; WHEN THERE'S A SHORTAGE, STALKS ARE WEAK, SPINDLY AND OFTEN BARREN OF EARS



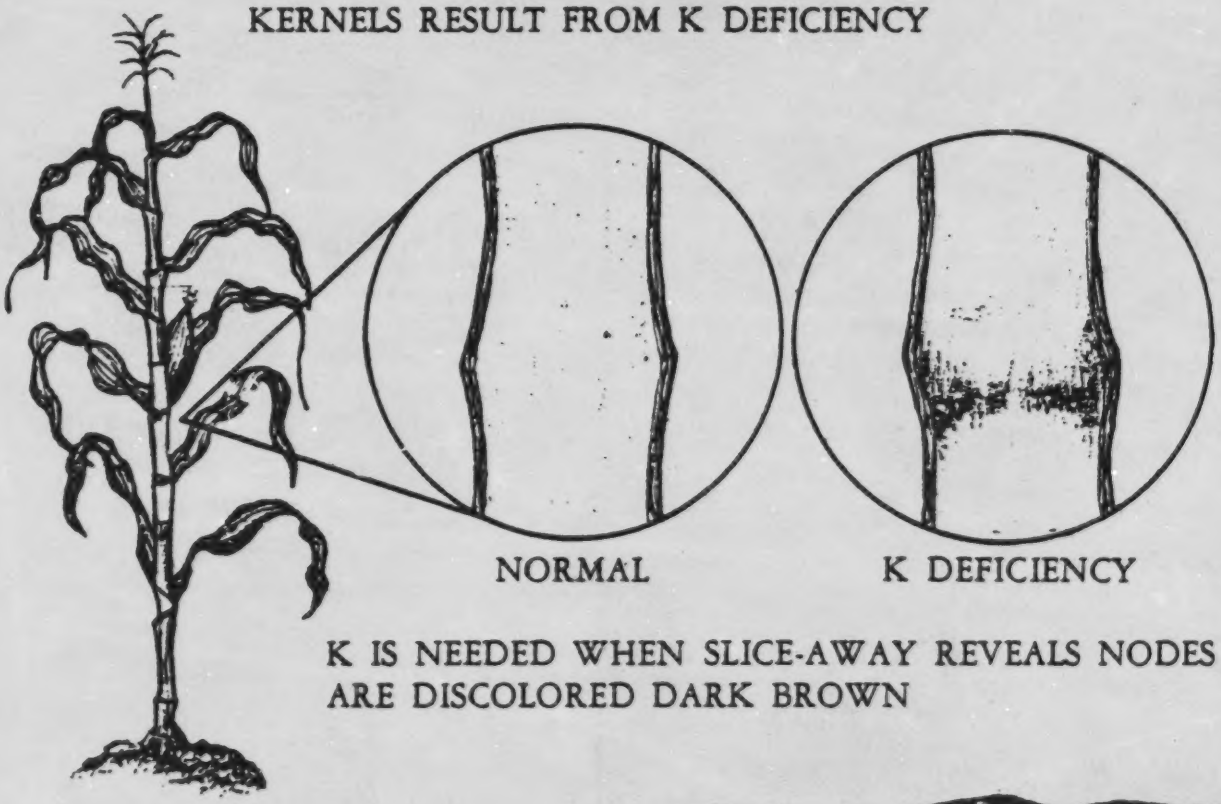
P IS NEEDED WHEN EARS ARE SMALL AND TWISTED AND KERNELS ARE UNDEVELOPED



P SHORTAGE DURING EARLY WEEKS CAUSES A SHALLOW ROOT SYSTEM WITH LITTLE SPREAD

POTASH deficiency in corn

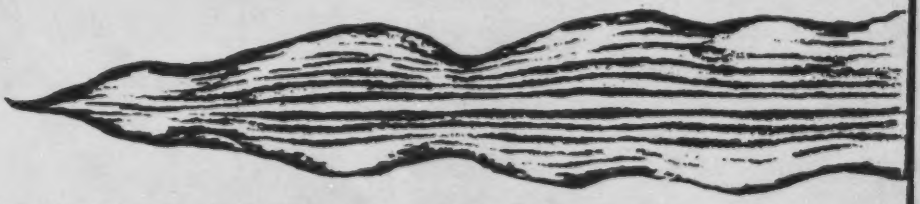
POORLY FILLED TIPS AND LOOSE CHAFFY KERNELS RESULT FROM K DEFICIENCY



NORMAL

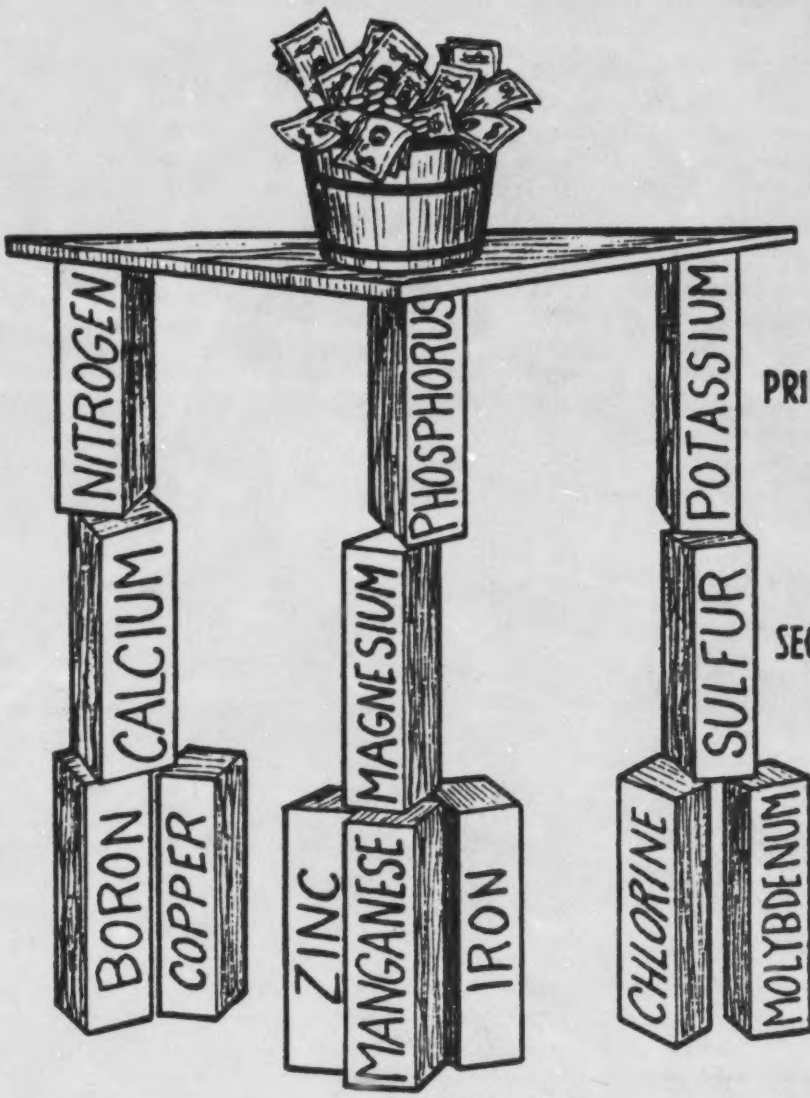
K DEFICIENCY

K IS NEEDED WHEN SLICE-AWAY REVEALS NODES ARE DISCOLORED DARK BROWN



K DEFICIENCY CAUSES FIRING OR DRYING ALONG THE TIPS AND EDGES OF LOWEST LEAVES

PROFITS CAN FALL IF ANY NUTRIENT IS SHORT



PRIMARY PLANT NUTRIENTS

SECONDARY PLANT NUTRIENTS

MICRO PLANT NUTRIENTS

Topic 9: Inorganic and Organic Fertilizers - Types and Blends

Suggested Procedure and Activities: Have samples of the fertilizers available. Use pictures, film, or a field trip to show the results of the fertilizer used.

1. The Main Difference Between Inorganic and Organic Fertilizers

   a. Inorganic fertilizers are composed of matter other than plant and animal substances. Most fertilizers are made from inorganic chemical products. Inorganic fertilizer is commonly known as chemical fertilizer.

   b. Organic fertilizers are usually derived from plant and animal residues. Organic materials contain carbon compounds. Carbon containing fertilizers, such as calcium cynamide and urea, are produced synthetically. Organic materials from plant and animal are not produced in sufficient quantities to supply adequate plant nutrients for the farmer; therefore, the less inorganic materials supply his needs.

   c. The chemical element is usually higher in inorganic fertilizers than organic fertilizer materials. Even though inorganic fertilizers contain a greater quantity of plant food nutrients by weight than organic fertilizers, the cost per pound of nutrient is less for inorganic fertilizers. The commercial value of most inorganic fertilizers is based chiefly on the content of the nitrogen, phosphorus, and potassium in the fertilizer mixture.

Transparency No. 1

2. Sources of Nitrogen

   a. Ammonium Sulphate - $(NH_4)_2\ SO_4$)

      (1) Formula 21-0-0 - a solid nitrogen fertilizer.
      (2) This fertilizer does not absorb as much water as do some fertilizers, and it is a good source of nitrogen in mixed or fertilizer blends.
      (3) All nitrogen is in the ammonium form, and it is soluble in water.
      (4) It is made by reacting sulphuric acid with ammonia. It tends to increase the soil acidity due to its sulfur content.

   b. Anhydrous Ammonia - (NH_3)

      (1) Formula 82-0-0 - a gaseous form of nitrogen.
      (2) Anhydrous ammonia is a liquid stored under pressure in air tight metal containers. It becomes a gas after being released from the container.
      (3) It is used to make many of the solid forms of nitrogen fertilizers.

   c. Nitrate of Soda - $(NaNO_3)$

      (1) Formula 16-0-0 - a solid nitrogen fertilizer material.

(2) A highly available form of nitrogen that is more readily available in cool weather than most nitrogen fertilizers.
(3) As Nitrate of soda (sodium nitrate) decomposes, it leaves an alkaline condition in the soil.
(4) It is manufactured synthetically and mined from the soil.

d. Aqua Ammonia or Ammonia Liquor - (NH_4oH)

(1) This fertilizer contains about 25 percent nitrogen, and it is formed by dissolving anhydrous ammonia in water.
(2) The ammoniated solution is used in making fertilizer mixtures.

e. Ammonium - Nitrate - (NH_4NO_3)

(1) Formula 33.5-0-0 - A solid fertilizer material.
(2) Since ammonium nitrate is completely water soluble, it is one of the fast-acting fertilizer materials.
(3) It is made by oxidizing ammonia with nitric acid.
(4) Ammonium nitrate is considered to be highly explosive; therefore, it should be stored out of the way of man and animal.

f. Ammonium Phosphate - ($NH_4H_2PO_4$) or ($(NH_4)_2HPO_4$)

(1) Formulas 11-48-0, 21-53-0 and 16-20-0 - a solid fertilizer.
(2) Ammonia is reacted with phosphoric acid (H_3PO_4) to form ammonium phosphate.
(3) Phosphates tend to increase soil acidity; therefore, they may be tied up in the soil if pH is below 5.5.

g. Urea - $CO(NH_2)_2$

(1) Formula 45-0-0 - a solid organic nitrogen fertilizer.
(2) Urea is made from ammonia and carbon dioxide. It is a synthetic nitrogenous fertilizer.
(3) It hydrolyzez readily to the amonia form, and it is later converted to the nitrate form.
(4) Urea is considered an organic material; in that, it contains carbon.

h. Calcium Cyanamid - ($CaCn_2$)

(1) Formulas 21-0-0 and 22-0-0 - a solid nitrogen fertilizer.
(2) Like urea, calcium cyanamide is a synthetic nonprotein organic nitrogen fertilizer.
(3) It can be used as a defoliant, herbicide and as a disease control measure for some soil-borne diseases.

Transparency No 1

3. Sources of Phosphorus

a. Superphosphate - A P_2O_5 equivalent of 16 to 22 percent phosphoric acid for normal superphate and 40 to 50 percent of phosphoric acid for double superphosphate.

Concentrated superphosphate is 42 to 50 P_2O_5.

(1) Formulas 0-20-0 - normal and 0-45-0 double superphosphate. (Phosphorus and sulfur).
(2) Superphosphate is made by treating phosphate rock with sulfuric acid.

b. Liquid Phosphoric Acid

(1) Formulas 0-52-0 and 0-54-0 - a liquid phosphoric acid.
(2) This fertilizer's effectiveness is about the same as superphosphate.

c. Nitric Phosphate

(1) Formulas 14-14-0, 20-20-0, and 20-10-0. It usually has a grade of 14-14-0.
(2) When potassium is added, the formulas are 12-12-12, 16-16-8, and 14-14-14.
(3) This fertilizer is usually made by preparing a mixture of superphosphate with nitric acid.

d. Other Sources of Phosphorus

(1) Colloidal Phosphate - A solid material from rock phosphate washings. It contains about 20 percent total P_2O_5. Collodial phosphate is recommended for acid soil.
(2) Basic Slag - A solid material which is a by-product of the steel industry. It contains between 8 and 12 percent available P_2O_5.
(3) Ammonium Phosphate - A solid material made by treating phosphoric acid and anhydrous ammonia. There are two grades of this fertilizer and one grade that contains sulphate. The grades are as follows:

Monophosphate is 11-48-0 and 13-39-0.
Diammonium phosphate is 21-53-0.
Ammonium phosphate - sulphate is commonly known as 16-20-0.

Ammonium phosphates are used with other fertilizer materials to make complete commercial mixtures. It is necessary to add potash to form a complete fertilizer mixture.

Transparency No. 2

4. Sources of Potassium

a. Muriate of Potash - (KCI) or Potassium Chloride.

(1) Formula 0-0-60 - a solid potash fertilizer.
(2) This is the most common source of potash fertilizer material, and it is relatively inexpensive as compared to other fertilizer materials.

b. Sulphate of Potash - (K_2SO_4) or Potassium Sulphate.

(1) Formula 0-0-50 - a solid fertilizer material. It is usually equivalent to 50 percent potash.
(2) If the chlorine content of muriate of potash is injurious to crops, potassium sulphate is used.

c. Other Sources of Potassium Include:

(1) Nitrate of Potash - (KNO_3) or potassium nitrate. It contains about 13 percent nitrogen and 44 percent potash. Potassium nitrate is a solid material that is produced as a by-product in refining nitrate of soda.

(2) Potassium - Magnesium Sulphate - This is a solid material that contains the equivalent of 21.75 percent potash. The magnesium oxide equivalent is 18.75 percent. The magnesium and potash are water soluble.

(3) Potassium - Sodium Nitrate - This fertilizer is a mixture of potassium nitrate (KNO_3) and sodium nitrate ($NaNO_3$). It contains 14 percent potash and 14 percent nitrogen. The nitrate of soda and potash mixture is a by-product from refining nitrate ore.

(4) Potassium phosphate - This fertilizer material is considered very high in potassium. (K).

Transparency No. 2

5. Sources of Calcium

a. Limestone - Lime is manufactured from limestone, marl, or oyster shell. Calcite is limestone containing calcium carbonate ($CaCO_3$) and dolomite, another liming material contains calcium carbonate ($CaCO_3$) and magnesium carbonate ($MgCO_3$).

b. Calcium Nitrate - ($Ca(NO_3)_2$). This fertilizer contains about 17 percent nitrogen. Nitric acid is reacted with limestone, to form calcium nitrate. It contains about 34 percent lime or calcium oxide.

c. Superphosphate - This fertilizer contains about 20 percent calcium when in the ordinary form. Triple superphosphate contains about 12 percent calcium.

d. Gypsum - ($CaSO_4 \cdot 2H_2O$) - A solid fertilizer material used as a soil liming material. Gypsum is hydrated calcium sulphate.

e. Calcium Cyanamid - (CaCN2) - There is 38.5 percent calcium in this material.

6. Other Plant Nutrients and Their Source of Supply

a. Sulphur may be supplied through elemental sulphur, gypsum, ammonium sulphate, and superphosphate.

b. Magnesium is supplied in limestone and through magnesium sulfate.

c. Zinc is supplied by zinc sulfate.

d. Iron is supplied mainly by iron chelates. (A chelate is an organic compound which combines with metal in such a way as to keep the metal in an available form.)

e. Copper is supplied through copper sulfate.

Transparency No. 3

7. Blends of Fertilizer - A complete fertilizer contains nitrogen, phosphorus and potassium.

a. A 12-24-12 Blend

(1) The first 12 represents the percentage of nitrogen in the fertilizer. If you had a 50-pound sack, there would be 6 pounds of nitrogen, because 12 percent of 50 is 6.
(2) The 24 represents the percentage of phosphorus.
(3) The last 12 represents the percentage of potassium.

b. Fertilizer Ratios

(1) 13-13-13 is known as 1-1-1 ratio. In all 1-1-1 fertilizers the three major plant foods (nitrogen, phosphorus, and potassium) are contained in equal parts.
(2) 10-20-10 is known as a 1-2-1 ratio. In this ratio there is twice as much phosphorus as there is nitrogen or potassium.
(3) 20-10-10 is known as a 2-1-1 ratio.
(4) If a soil test report recommended that 120-60-60 be used, this would require a 2-1-1 ratio. If a 20-10-10 was used, it would mean that six 100 pound sacks would be required to supply the 120-60-60.

8. Organic Fertilizers are Derived from Plants and Animals

a. They, for the most part, are insoluble in water.
b. Materials used as organic fertilizers are:

(1) Cottonseed meal - a by-product of cottonseed milling. It contains about 7.0 percent nitrogen, 3.0 percent phosphoric acid and 2.0 percent potash.
(2) Guano - The dried excrement from birds and bats. It is high in phosphate and nitrogen.
(3) Tankage - Animal meat scraps and other body residue are high in nitrogen, but they are generally used in feeds.
(4) Bone meal - The amount of calcium and phosphorus available depends upon how fine the bone is ground.
(5) Manure - The excreta of animals is usually low in the major elements when comparing it to chemical fertilizers.
(6) Green manure crops - Crops turned under the soil while still green. This kind of fertilizer is normally higher in price than chemical fertilizers.

c. The nitrogen in organic fertilizers are slowly available.

COMMON SOURCES OF INORGANIC FERTILIZER MATERIALS

NAME	APPROXIMATE PERCENT OF NITROGEN
AMMONIUM SULPHATE	21
ANHYDROUS AMMONIA	82
NITRATE OF SODA	16
AQUA AMMONIA	16 – 25
AMMONIUM NITRATE	33.5
AMMONIUM PHOSPHATE	11 – 21
UREA	45
CALCIUM CYANAMID	21

NAME	APPROXIMATE PERCENT OF PHOSPHORUS
SUPERPHOSPHATE (Normal)	16 – 22
SUPERPHOSPHATE (Concentrated)	42 – 50
LIQUID PHOSPHORIC ACID	54
NITRIC PHOSPHATE	10 – 22
COLLOIDAL PHOSPHATE	20
BASIC SLAG	8 – 12
AMMONIUM PHOSPHATE	20 – 39
MONOPHOSPHATE	48
DIAMMONIUM PHOSPHATE	48 – 53

COMMON SOURCES OF INORGANIC FERTILIZER MATERIALS

NAME	APPROXIMATE PERCENT OF POTASSIUM
POTASSIUM CHLORIDE (Muriate)	60
POTASSIUM SULPHATE	50
POTASSIUM NITRATE	44
POTASSIUM—MAGNESIUM SULPHATE	22
POTASSIUM—SODIUM NITRATE	14
POTASSIUM PHOSPHATE	48

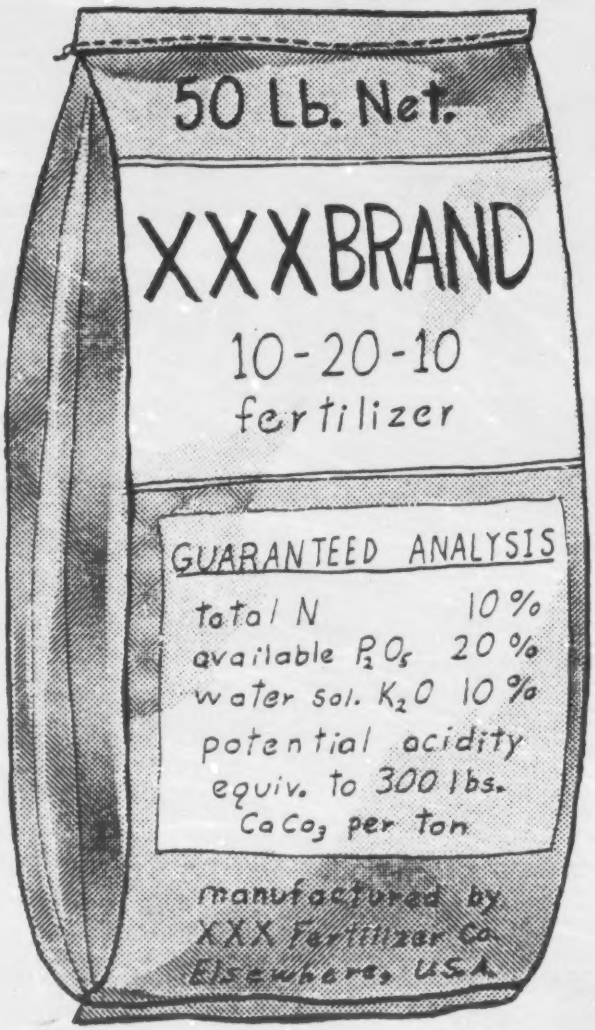
NAME	APPROXIMATE PERCENT OF CALCIUM
LIMESTONE	31.7
CALCIUM NITRATE	34
SUPERPHOSPHATE	20
CALCIUM SULPHATE (Hydrated Gypsum)	22
CALCIUM CYANAMID	38.5

PLANT NUTRIENT BLENDS

13 N — 13 P_2O_5 — 13 K_2O = 1—1—1 Ratio

13 Lbs. of Each Primary Nutrient = 39 Lbs. per 100 Lbs. of Fertilizer

INFORMATION COMMONLY FOUND ON A FERTILIZER BAG



LBS. PER BAG

TRADE NAME OR BRAND

GRADE

GUARANTEED CHEMICAL COMPOSITION

ACID FORMING TENDENCY

NAME & ADDRESS OF MANUFACTURER

Topic 10: Methods, Rates, and Time of Application

Suggested Procedure and Activities: Use slides or filmstrips to show the various methods of application (equipment manufacturers and the Fertilizer Institute have such filmstrips; however, your own slides from your local area will be more effective).

1. Why It Is Just As Important to Apply Fertilizer Properly as Using the Proper Fertilizer Analysis.

   a. The correct method of application may determine whether or not the nutrient is made available to the plant. For example, spraying phosphate solutions on the soil or broadcasting the phosphate and mixing it in the soil may cause fixation. Phophorus may unite with hydrated iron oxides causing it not to be released for plant use. About 20 percent of the phosphorus is used during the year that it is applied.
   b. An improper application of fertilizer may result in a complete loss of the applied plant food nutrient. If the fertilizer is not in reach of the plant roots and it is not dissolved by moisture in the soil, it can be considered as a loss to the plant.
   c. Placing fertilizer too close to the root system or seed may result in damage to the plant or seed.
   d. Liquid and gaseous fertilizers should be placed so that it can be absorbed in the soil. If the soil is too dry the gaseous fertilizers tend to escape; and if the soil is too wet, the ammonia gas cannot penetrate the soil to make absorption complete.
   e. Fertilizer should be placed at a safe distance from the plant, and applied at the proper time during the year if the plant is to give the maximum response from its use.

2. Why Fertilizer

   a. Usually results in higher crop yields.
   b. Fertilizers usually stimulate early growth, getting plants off to a good start.
   c. Help plants to become established.
   d. A complete fertilizer provides necessary plant food elements.
   e. The palatability of the crop is normally improved.
   f. Increases the nutritive value of the plant grown. An example is the nitrogen in the soil which makes for a higher percentage of protein in the plant.
   g. Certain fertilizers and lime influence the pH of the soil.
   h. Fertilizers help to keep out some of the undesirable plants while the desirable plants increase.
   i. The proper use of fertilizers usually increases profits.

3. Fertilizer Distributing Equipment Should Have Certain Features That Make Them Desirable

   a. They should have an adjustment so that the rate of flow will be uniform.
   b. The controls should be easily regulated. Applications need to be uniform and in the correct amounts.

c. The various forms of fertilizer (pellets, granules, powder) should be distributed with the same equipment.
d. Should be large enough to hold a large quantity to prevent refilling.
e. A good agitator is important to keep the materials stirred and flowing at the desired rates.
f. The equipment should function the same when full or nearly empty.
g. The equipment should have windows or gauges that show the amount of flow or when the hopper is empty.

4. The Methods of Applying Fertilizers

a. The methods of application are influenced by the following factors:

(1) Phosphorus moves very slowly from the place of placement, so it should be placed in moist soil throughout the period that it is used by the plant.
(2) Nitrate nitrogen moves with the soil moisture, and the ammonium forms of nitrogen are absorbed by clay particles and held against movement.
(3) Plant nutrients are lost more easily by leaching in sandy soils than in heavy-textured soils; therefore, applications of fertilizer are made more frequent on sandy soils than clay soils.
(4) In order that the seedlings may take a rapid growth fertilizer is placed near the young seedling roots. Excessive concentrations of fertilizer too close to the seed or seedling; however, could result in damage to the plants.
(5) Surface application of fertilizers may result in a loss of the nutrient elements by heavy rainfall.
(6) Crops in marginal dry areas do not respond readily to to fertilizers. Solid fertilizers remain inactive on dry soils until moisture is available.
(7) Minor elements such as zinc, copper, and manganese can be absorbed through the leaves of plants.

Transparencies No. 1,2, and 3

b. Fertilizer placement depends upon the type of crop to be grown, the type of soil, type of equipment on hand, and seedbed preparation. Methods of application include:

(1) Banding - A band of fertilizer is placed either 2 to 3 inches to the side and 2 to 3 inches below the seed, or it is placed 3 to 6 inches below the seed.
(2) Topdressing - Nutrients are supplied to small grains, legumes, and grasses by drilling them into the top soil. A drill attachment is used to apply fertilizer by this method. Topdressing small grains is similar to side dressing row crops.
(3) Sidedressing - Sidedressing is usually restricted to the application of nitrogen and potassium. Where cultivation is practiced, sidedressing is usually done about the time of the first cultivation. Side-

dressing reduces the loss of plant nutrients by leaching. It can be done when the moisture conditions are favorable. The main precaution is not to place the fertilizer too close to the plant. Sidedressing can be done 2 to 4 weeks after planting.

(4) Broadcasting - Fertilizer is usually applied to pastures by the broadcast method. After the fertilizer is applied to the surface, it may be disked into the soil. Clay soils reduce the availability of phosphorus to the plant growth, that is, if the phosphorus is broadcast instead of banded.

(5) Applying in Irrigation Water - Nitrogen can be applied to the soil efficiently and evenly by adding it to the irrigation water. Since phosphorus tends to remain on the surface, it is usually applied by other methods.

(6) Foliage Spray - Foliar feeding of plants is generally satisfactory for applying most trace elements directly to the leaves. The major elements cannot be applied in this method due to so many applications being required to furnish a sufficient amount of plant nutrients.

(7) Aerial Applications - Areas with rough land or dense froest can be fertilized by plane. Usually coarse, granular or pelleted material is used for aerial distribution. This form of application is considered a broadcast method.

Transparency No. 4

5. The Amount of Fertilizer to Use

a. The amount of fertilizer to use in order to obtain a profit depens upon the following factors: Soil type, past management practices, climatic conditions, and the amount of capital the producer has to invest.

b. Fertilizer is used to increase the yield of a crop. Soil tests are generally used to indicate the amount of fertilizer necessary for a given response. Yields continue to increase as more fertilizer is used up to a certain point, then they start to decrease.

c. Available Moisture Expected for Growth

(1) The more moisture that is available, the more fertilizer that can be used profitably.

(2) Plant nutrients must be in solution before the plants can use them.

d. Grazing or utilization management practices may include:

(1) Continuous overgrazing limits the good response that may be obtained from proper fertilization.

(2) Keeping plants grazed too short restricts their root system and prevents their making use of available plant nutrients.

(3) Under grazing or under utilization results in wasted forage and loss of plant nutrients.

e. Expected per unit price of the livestock products to be sold.

7. Important Things to Consider When Applying Fertilizer

   a. Apply fertilizer needs as indicated by a soil test.

   b. Improper or incorrect applications may cause lowered crop yields.

   c. Commercial fertilizers may be toxic to the plant or seed if they are in direct contact with it.

   d. Commercial fertilizers are more injurious to some plants during dry years because of the high salt concentration.

   e. Soil type should be considered when applying fertilizers.

      (1) Soils that are loose and porous (sandy soils) lose a large amount of nutrients through leaching.
      (2) Heavier soils (clay), having less percolation of water through the soil, lose smaller amounts of nutrients through leaching.
      (3) Fertilizer applications on sandy soils should be delayed until the planting season, but fertilizers can be applied on heavier soils well ahead of planting time.

   f. The types of nutrients being applied cause the time of application to vary.

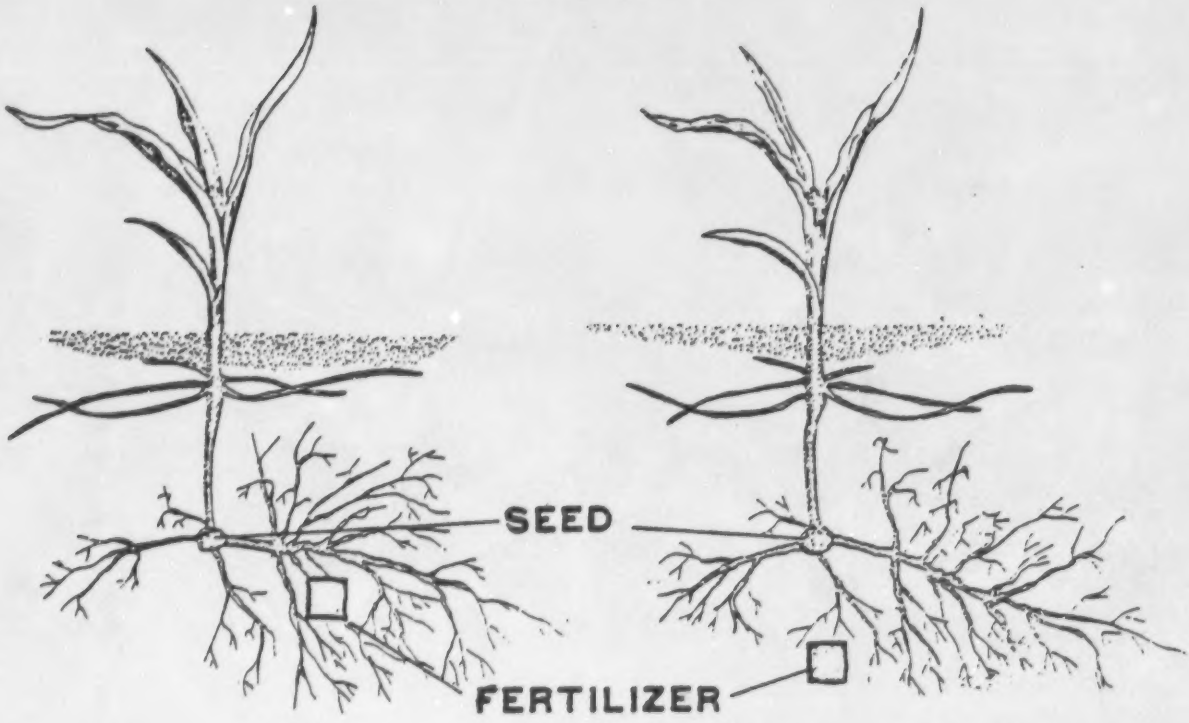
      (1) Most grasses need to be fertilized after each utilization period if they are to produce another crop during the same growing period (i.e. grass that has been cut for silage and is to be used for pasture through the summer).
      (2) When the pasture has a lot of growth and part of the root system dies and other forms of organic matter are available, sufficient nitrogen should be applied to help in the decomposition.

   g. Fall or spring applications of pastures

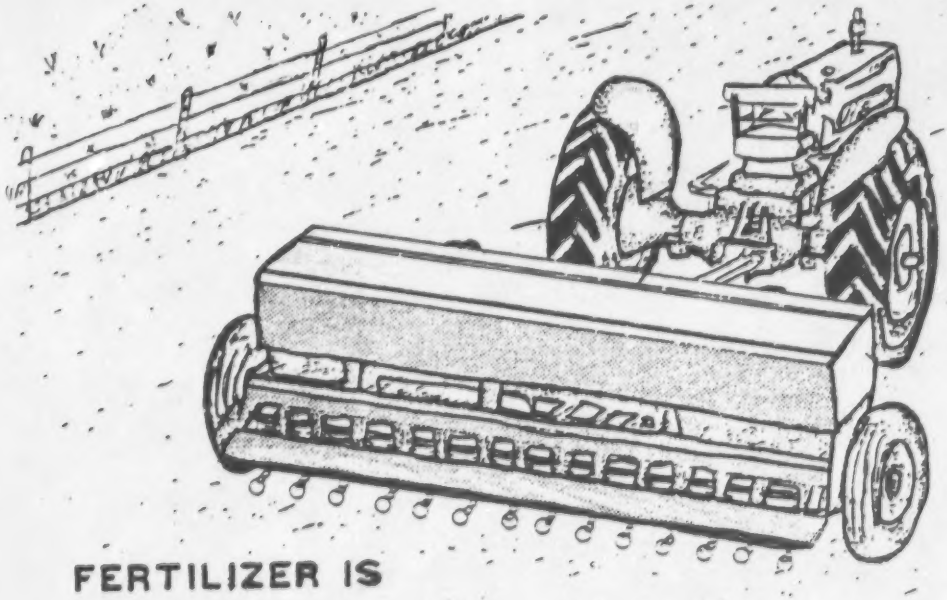
      (1) Light amounts of phosphorus and potassium fertilizers are used in the fall to help root growth and reestablish the plant.
      (2) Spring application will help get the plants off to a good start and will provide an abundance of leafiness.
      (3) When legumes are included in the pasture, extra nitrogen may not be needed.

APPLICATION OF FERTILIZER

Band of Fertilizer



TOP-DRESSING FERTILIZER



FERTILIZER IS COVERED

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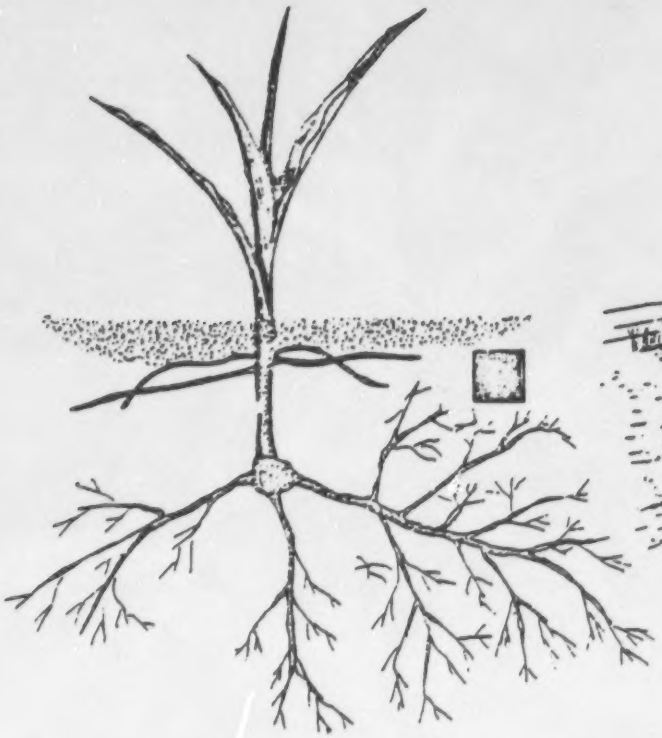
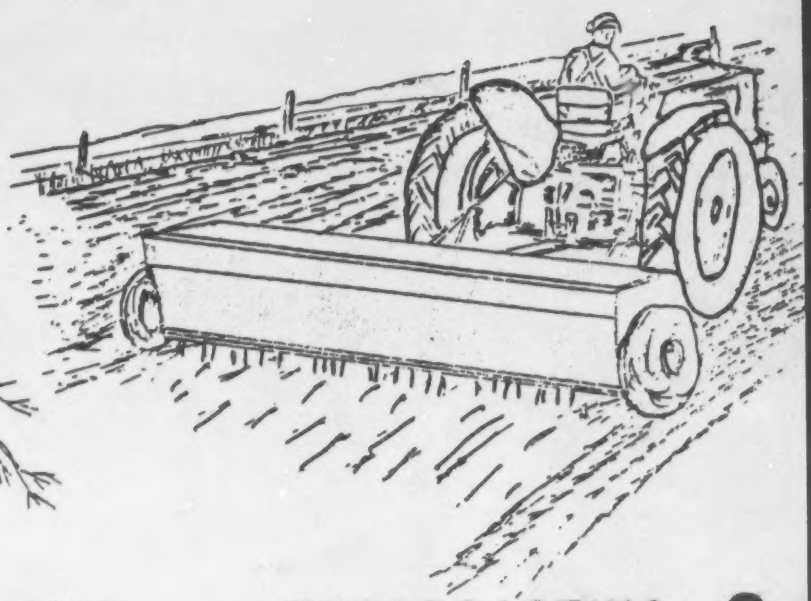
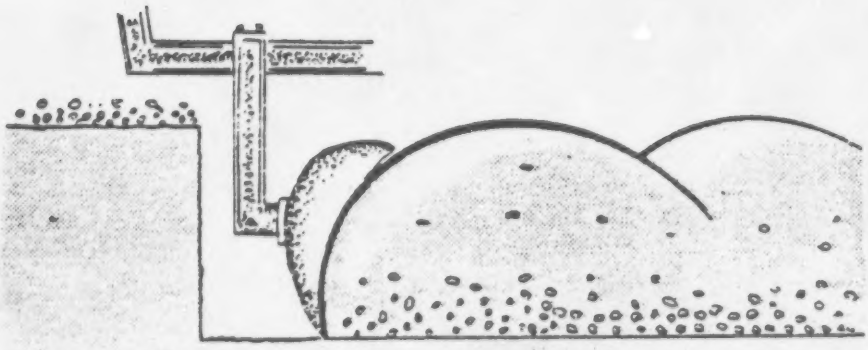
APPLICATION OF FERTILIZER



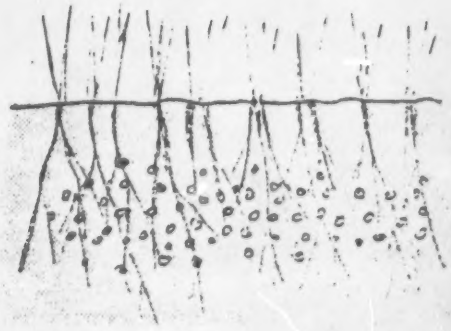
SIDE-DRESSING FERTILIZER



BROADCASTING

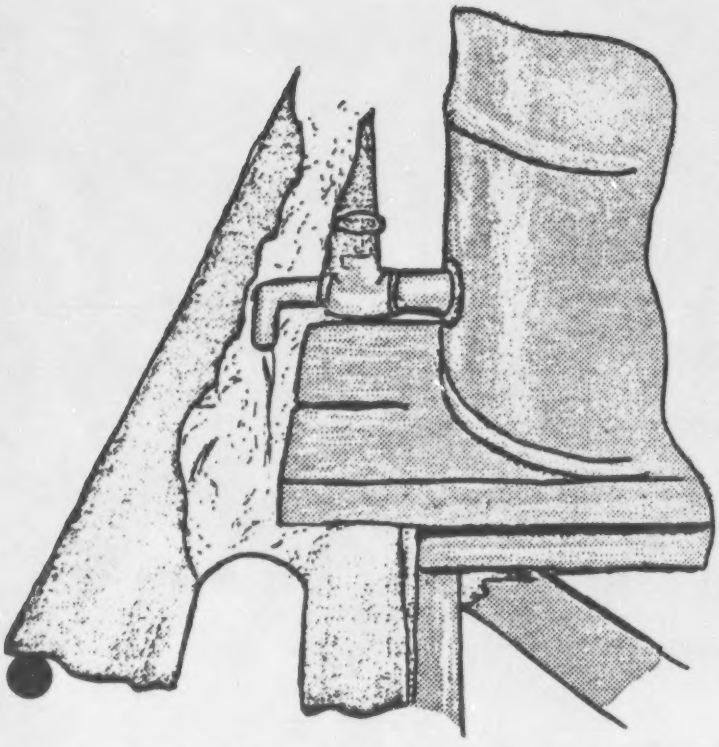


PHOSPHORUS PLOWED INTO TOPSOIL

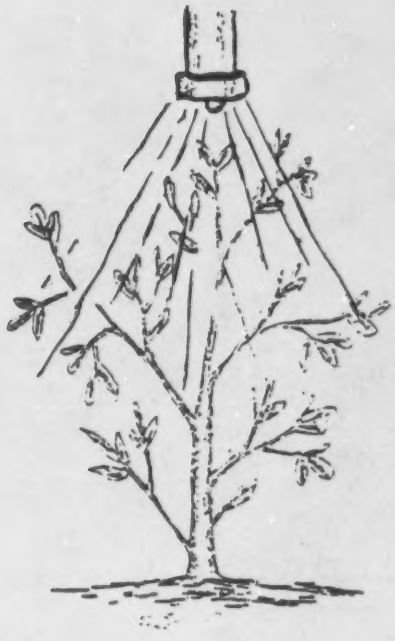


PHOSPHORUS AVAILABLE TO ROOT SYSTEM

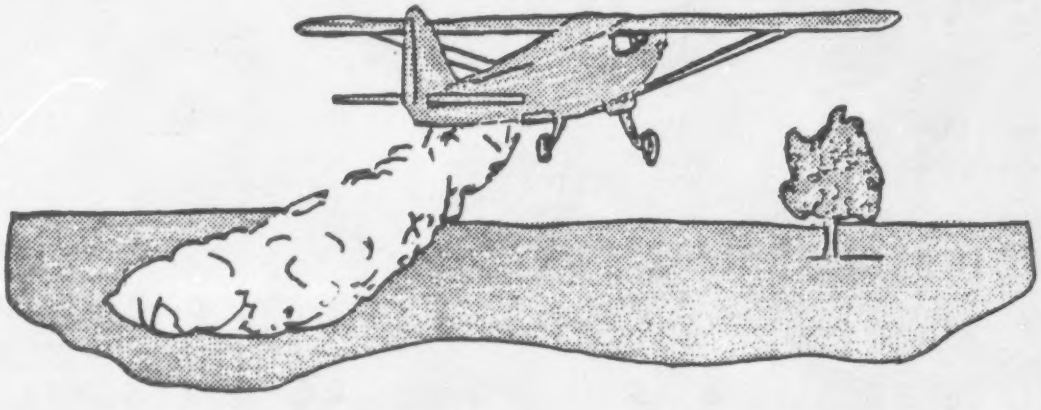
APPLICATION OF FERTILIZER



APPLYING FERTILIZER TO IRRIGATION WATER

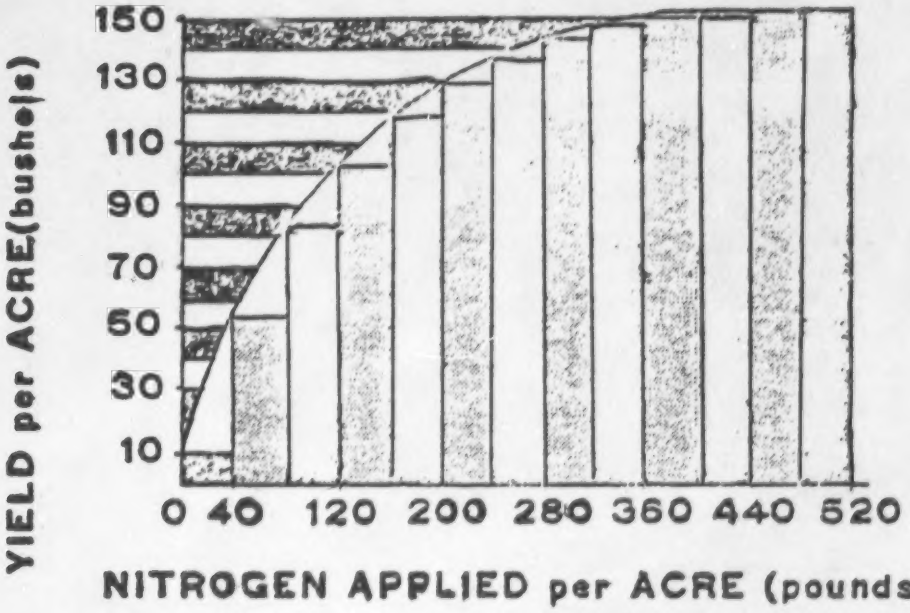


FOLIAGE SPRAYING

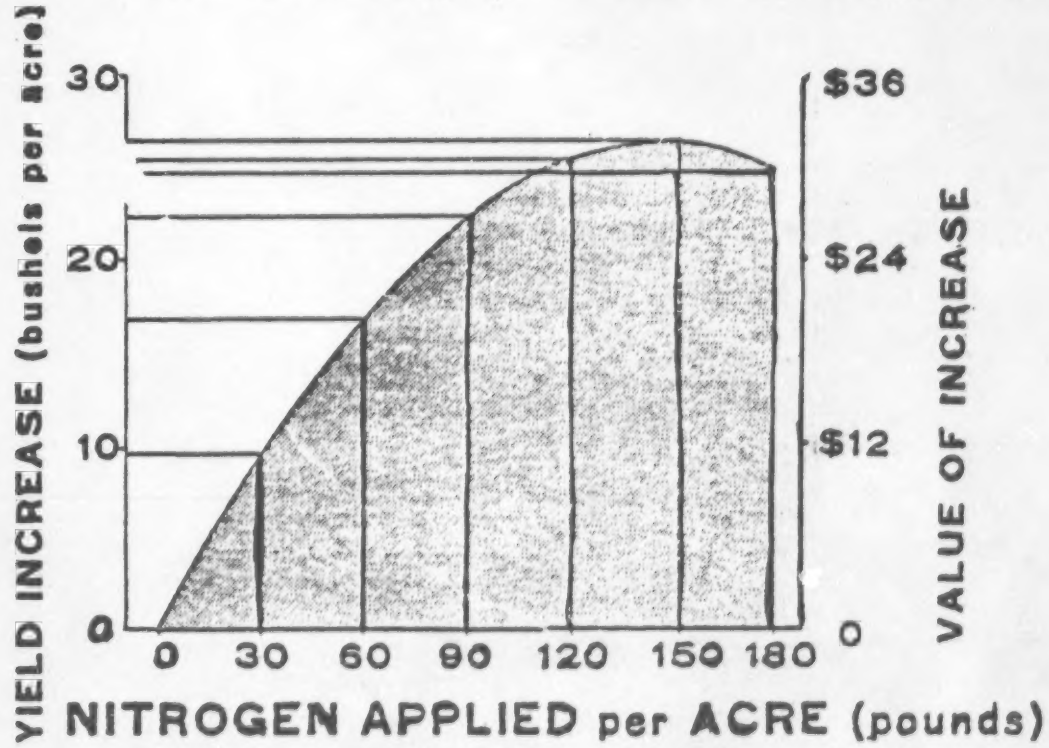


APPLYING FERTILIZER BY AIRPLANE

AMOUNT OF FERTILIZER TO USE



Response diminishes per acre at 280 pounds.



Peak of nitrogen application per acre.

THE FOLLOWING MATERIALS ARE AVAILABLE FROM THE
OREGON STATE UNIVERSITY EXTENSION STOCK ROOM,
WRITE FOR THEM AT:

EXTENSION BUSINESS OFFICE
EXTENSION HALL 118
OREGON STATE UNIVERSITY
CORVALLIS, OREGON 97331

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MANUAL FOR JUDGING SOILS IN OREGON

J. H. Huddleston

G. F. Kling

September, 1980

Oregon State University Extension Service

in cooperation with the

Department of Soil Science

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CHAPTER 1. THE SOIL WE STUDY

Soils are different from most other natural resources. You can easily see vegetation, you can quickly tell the difference between one animal and another. With your senses of sight, smell, and taste you can readily assess general differences in air or water quality. But you can't see, smell, or feel the soil until you make the effort to dig a hole or scrape off a road cut. So you have to have a good dose of curiosity to want to study the soil. A lot of people don't have that curiosity, and a lot of people simply take the soil for granted without realizing that their very existence depends on the soil. For the curious, though, opening up a soil pit reveals a unique and fascinating world unlike any other. Opening up several pits reveals that soils are different--often very different. These differences mean that we cannot expect the same crop yields for all soils; we cannot expect to manage all soils the same way, and we cannot expect all soils to be equally suitable for building streets and houses. To study the soil, then, is to explore a new world, to better understand how it works, and to better manage a vital natural resource.

WHAT IS SOIL?

Soil has been defined by lots of different people in lots of different ways. One very simple definition is "the natural medium in which plants grow." That, however, is a bit of an oversimplification. A somewhat more comprehensive definition is: Soil is a natural body, worthy of study in its own right, which has developed in profile form from a mixture of weathered minerals and decaying organic matter. It covers the earth in a thin layer and supplies plants with air, water, nutrients, and mechanical support.

My definition is, of course, the one I prefer:

> Soil is a living, dynamic system, which forms at the interface between atmosphere and lithosphere in response to forces exerted by climate and organisms, acting through time, on a parent material situated in a specific landscape position.

I like this definition because each key word expresses something important about the soil. Why living? Because the soil is full of life and the products of life. Roots large and small, animals and insects, millions of microscopic fungi and bacteria, plus all the dead and variably decomposed organic matter which is so valuable in maintaining soil tilth and productivity. Dynamic says that the soil is constantly changing. Moisture levels fluctuate, organic matter is continually being added and decomposed, minerals are weathering, nutrients are being cycled and leached, pH changes seasonally. The system concept expresses interdependency between all the parts that make up the dynamic whole. Alteration of one part may cause changes in several other parts of the system. For example, a change in the amount of soil moisture affects aeration, temperature, root activity, microbial activity, bearing strength, and perhaps soil structure.

The notion of interface emphasizes that soil is indeed a very thin rind on the earth that forms at the planar surface where rock meets air. But what an important rind! Nathaniel Shaler (1915) says it this way: "Soil . . . is a kind of placenta that enables living things to feed upon the earth." Or in Russell Lord's words (1962), "Soil is living rock, the earthly borderline between the quick and the dead." These are powerful analogies!

The rest of the key words tell something about how soil forms. It is indeed the result of a force-response relationship. Something pushes the system, and something else responds. Of the five factors of soil formation, climate and organisms are the active factors. They provide the forces of dynamic change. Climate exerts its effect mainly as temperature and rainfall. Together they influence rates of weathering, leaching, plant growth, and decomposition. Organisms influence soil color and soil fertility, and are instrumental in formation and accumulation of humus in soils. Organisms also contribute to the formation of surface soil structure, which in turn influences water infiltration and retention. And they contribute to weathering processes.

The remaining three factors are passive factors. Parent material is the primary respondent to active forces. It is the original material that has since been changed into the soil we study today. It may be some kind of bedrock, or it may be an alluvial sediment or a glacial deposit derived from rock by geologic erosion. Parent material exerts a strong influence on the texture and chemical makeup of a soil early in its formation. Later, the influence of parent

material diminishes. Thus time as a factor of soil formation also has a passive effect. With the passage of time soils tend to become more weathered, more leached, more acid and more clayey; in a nutshell, more developed. Landscape position, or topography, is also a geologic factor which influences soil development. Its effect is exerted mainly as an indirect climatic effect. Thus soils on north-facing slopes tend to be cooler and wetter than soils on south-facing slopes, and soils on concave footslopes that receive extra water from runoff or seepage are wetter than soils on convex summits.

WHY SHOULD WE EVALUATE SOIL PROFILES?

Soil profiles are like history books. They contain records of everything that has happened to the soil since it began to form from a parent material. Their pages are the kinds of horizons and the colors, structures, textures, and other chemical and physical properties that we examine in the field and in the laboratory. Sometimes the record is difficult to read and decipher, because so many different processes have acted and interacted simultaneously for varying lengths of time, and the soil we see is an integrated expression of the cumulative effects of all these things. Nevertheless, we have learned a great deal about how to read the story told by the soil; it is that knowledge we draw upon in soil evaluation.

The soil profile tells us something about how the soil formed, about its inherent qualities for various uses, and about its behavior under management for applied objectives. This is true whether we are planning to use soils for agricultural production, for constructing houses and septic tank drainfields, or for constructing logging roads in forests. The first step in successful soil management, therefore, is a thorough evaluation of the soil profile.

HOW DO SOIL PROFILES DEVELOP?

Our definition of soil has identified five factors of soil formation. We can also think in terms of processes that together change geologic parent material into life-sustaining soil. There are four major kinds of processes: Additions, Losses, Translocations, and Transformations.

The most obvious addition is organic matter. As soon as plant life invades fresh parent material, organic matter begins to accumulate. Organic matter imparts a black or dark brown color to surface soils, and this is why even very young soils usually have a darker-colored surface layer. Other additions include salts left from evaporation of sea-spray, nitrogen added with rainfall, iron carried into the soil by laterally moving groundwater, or sediments deposited by flooding streams.

Losses occur when fresh organic matter decays, giving off oxygen and water vapor. They occur in wet soils when nitrogen is changed to a gas and escapes to the atmosphere. Wind and water erosion strip the soil surface of organic matter, mineral particles, and the nutrients they are holding. In humid environments, water moving downward through the soil dissolves some of the minerals and carries them out of the soil into the groundwater. This is a process called leaching. Leaching accounts for the early loss of very soluble salts (like table salt), for the removal of carbonates (free lime), and even for the loss of a portion of applied fertilizers.

Translocations result from incomplete leaching. In climates where water rarely moves all the way through the soil to the groundwater, minerals may be removed from the upper part of the soil and redeposited lower in the soil. Subsoil accumulations of free lime form this way. So do some hardpans. In wet soils of arid regions, evaporation may actually cause water to move upward in the soil, carrying soluble salts to the surface. These salty soils can pose difficult management problems. Other translocations occur when mineral particles are physically moved by leaching water. Very tiny clay particles can be moved into subsoils this way, where they form dark, waxy coatings called clay skins.

Transformations are changes that take place in the soil. Microorganisms that live in the soil feed on fresh organic matter, changing it into an altered, highly decomposed material called humus. Chemical weathering processes alter the original minerals of parent materials. They are destructive processes that account for the gradual decrease in content of primary minerals with increasing soil development. Some of the elements released by weathering may be leached out of the soil. Others may participate in further transformations by recombining into new minerals. Most of the clay particles in soils are actually secondary minerals

formed in this way. Still other transformations change the form of certain elements. Iron that is chemically oxidized imparts a reddish or yellowish-brown color to soils. Changing the soil environment to one without oxygen can cause reduction of the iron. Reduced iron has a grayish-blue color, often seen in very wet soils. Reduced iron is also relatively mobile in soils. Repeated cycles of wetting and drying can create a mottled pattern, whereby part of the soil is gray due to loss of iron, and part is yellowish-brown, where iron has reoxidized and precipitated.

The factors and processes of soil formation are not independent; they all act in concert with each other. Climate may strongly influence vegetation, and both together may dictate the rate and form of soil development. Weathering of parent materials is likely to be followed by some losses and some reconstitution as clay minerals. The clays in turn may be translocated lower in the profile.

The result of all these interactions is differentiation. Geologic material is differentiated into one or more layers to form a unique natural body called soil. The layers are called horizons. Each horizon has a unique set of physical and chemical attributes that reflect the integrated effects of all the factors and processes of soil development. Each horizon is distinguished from each other horizon by differences in one or more of its properties.

The soil profile is the sum total of all the horizons differentiated from geologic material by soil-forming processes. However, the profile may also be studied by examining borings taken with an auger or probe. If two soil profiles exhibit significant differences in either the kind or the sequence of soil horizons, then the soils themselves are different. In Oregon we have already recognized over 750 different soils, and with further study, the number will increase considerably.

CHAPTER 2. THE COMPONENTS OF SOIL PROFILES--SOIL HORIZONS

A soil horizon is a layer of soil that differs from layers above and below in characteristics such as color, texture, structure, and pH. Five general kinds of horizons may occur in soil profiles: O, A, B, C, and R. O horizons are composed primarily of organic materials. A horizons form relatively quickly at or near the surface of mineral soils. B horizons form more slowly in the subsoil, and often represent the maximum influence of all the soil-forming processes. C horizons are slightly altered geologic substrata below the zone differentiated by soil development. R horizons are layers of hard bedrock.

Soil horizons are named by combining one or two arabic numbers or lower case letters with the capital letters discussed above. A capital letter followed by an arabic number (e.g., A1, B2) indicates a specific kind of master horizon. A lower case letter (e.g., Ap, B2t, Cr) adds more information about the kind of master horizon. Sometimes a very thick horizon will be subdivided into two or more segments based on small changes in color, texture, or other properties. These vertical subdivisions are indicated with a second arabic number (e.g., A11, A12, B22t). Often a Roman numeral will precede the horizon name (e.g., IIB3, IIIC). This indicates that the soil profile cuts across different layers of original materials that have different geologic origins.

Rarely will a single soil profile exhibit all of the soil horizons that are possible. Usually a soil will have only two or three major diagnostic horizons and one or two transitional horizons. Some soils may have nothing more than an A horizon and one or more C horizons. Nevertheless, we must keep in mind all of the kinds of horizons that may occur in a soil, and that is what the following sections are for.

MAJOR KINDS OF O HORIZONS

O horizons are organic horizons of mineral soils. They are formed from accumulations of organic litter derived from plants and animals and deposited on the surface. In most soils these horizons are very thin, ranging from a few

millimeters up to 10 cm in thickness. There are two kinds of O horizons;

01 - An organic horizon of mostly undecomposed plant debris. The original form of most vegetative matter is readily visible and can be identified as to species. In forest soils, the 01 corresponds with the uppermost litter layer.

02 - An organic horizon in which plant and animal debris is so decomposed that neither the original form nor the species is recognizable. Humus is the major constituent, and there is usually very little mineral soil mixed with it.

MAJOR KINDS OF A HORIZONS

A horizons form at or near the soil surface either by accumulation of organic matter or by loss of certain soil constituents. Important kinds of A horizons are discussed below.

A1 - A surficial horizon of mineral soil formed by addition, decomposition, and incorporation of organic matter within the soil. Dark color, granular or platy structure, and friable consistence are typical characteristics. The thickness varies from a few centimeters to over 50 centimeters, depending on the amount and distribution of rainfall and the type of vegetation. A1 horizons are extremely important in sustaining soil fertility and physical condition, and should be protected from deterioration by erosion or compaction.

Ap - The plow layer of cultivated soils. Plowing thoroughly mixes the upper 20 to 30 centimeters of soil, destroying any original horizons that may have been present. In soils that have thick A horizons, the Ap may be underlain by an A12, an A2, or an A3 horizon. If the original A horizon(s) were thin, the Ap may rest directly on a B1, B2, or even a B3 horizon. In young, undeveloped soils, the only horizons present may be an Ap and one or more C horizons.

A2 - A light colored horizon characterized by loss of clay, iron, or aluminum relative to the horizons above and below. This horizon is not common in

Oregon soils, but it does occur in sandy soils along the coast and in some wet soils that have restrictive claypans or fragipans. In the sandy soils, the A2 is nearly white and lies between a dark colored surface horizon (02 or A1) and a Bir. In the wet, silty soils, water is perched on top of a restrictive layer, and lateral flow removes clay, iron, and organic matter.

A3 - A transitional horizon between the A and the B. It is dominated by properties of the A horizons above, but is beginning to take on some of the characteristics of the B horizon(s) below. The dark colors associated with organic matter are fading, and the structure may be grading from granular to subangular blocky.

MAJOR KINDS OF B HORIZONS

B horizons form mainly by transformations within them and by translocations of material from the overlying A. They are usually not as dark as the A,and they tend to have blocky or prismatic structures and firm consistence. Often the texture shows an increase in clay.

In most soils, the subsoil horizon that exhibits the greatest development is called the B2 (the only exception is Bx). Transitional horizons may occur both above and below the B2. The symbols B1 and B3 are used for these transitional horizons. Definitions for these master horizons are given below.

B1 - A transitional horizon between the A and the B2. It is dominated by properties of the B2, but still has some characteristics of the A. Commonly the structure is the same type as in the B2 but is not quite as strongly expressed. The color may still be a little darker than the B2 due to organic matter. Or the clay content may not be quite as high as in the B2. A soil may have either an A3 or a B1, but rarely will it have both transitional horizons.

B2 - A subsoil horizon that displays the maximum alteration by soil-forming processes. The symbol B2 by itself stands for a cambic horizon. This is a horizon typical of relatively young or weakly developed soils. The only evidences of alteration

in a cambic horizon are one or more of: a) an intensification of yellowish-brown colors; b) development of soil structure; c) leaching of carbonates.

Additional alterations in other kinds of B2 horizons may be expressed as an accumulation of clay, of iron-oxides, of organic matter, or of lime. Still others may be so wet as to have the characteristic called gleying. These kinds of alterations are indicated by adding a lower case letter to the symbol (e.g., B2t). The connotations of these letters are discussed more fully in the section on special kinds of A, B, and C horizons.

Bx - A B horizon that has the characteristics of a fragipan. This horizon is very dense, firm, and brittle. Dry peds seem to rupture or explode suddenly when pressure is applied. Silt loam is the most common texture. The fragipan is often mottled, and usually has streaks of gray silt throughout. Permeability is slow, so water perches above the pan. The fragipan is virtually impenetrable by plant roots, except in the gray silt streaks. In Oregon, fragipans occur only in some of the upland soils in Columbia, Washington, Multnomah, and Clackamas Counties.

B3 - A transitional horizon between the B2 and the C. It is dominated by properties of the B2, but the expression of effects of soil development is no longer maximum, and some of the influence of the original parent material is evident. Often the clay content is decreasing, or the color is fading, and the soil structure becomes coarser and weaker.

MAJOR KINDS OF C HORIZONS

The C horizon lies below the influence of most of the processes that differentiate parent material into A and B horizons. C horizons may be altered chemically, but they usually are outside the zone of major biological activity. Types of chemical alteration include weathering, gleying, accumulation of carbonates, and cementation by iron, carbonates, and silica. C horizons should lack clay skins, and they are likely to have very weak or massive structure.

Roots are often absent, though some deep rooted plants do extend roots into the C. Other features that may distinguish the C from the B are a change in pH, a decrease in clay, or an increase in free lime. Major kinds of C horizons found in Oregon are discussed below.

C - Weathered geologic material below the A and/or B horizons.

Ccasim or Csim - A C horizon that is cemented (m) by calcium carbonate (ca) and/or by silica (si). This horizon is called a duripan. It is common in several soils of eastern Oregon. Where fully developed, the duripan is just like hard rock, even though it is usually only a few inches thick. Thin, pinkish coatings of opal may be present on upper surfaces of duripan fragments. Duripans are impermeable to water and impenetrable by roots, and a dense horizontal root mat is one good indicator of a duripan. Some duripans, however, are discontinuous horizontally, and plant roots can find their way down through the more permeable cracks.

Cr - A C horizon that consists of either soft rock or weathered rock. Original rock structure can still be detected, but the material can be cut with a knife and dug with a spade.

SPECIAL KINDS OF A, B, AND C HORIZONS

It often happens that alteration of a given horizon is the result of a unique process that leaves a very distinct mark on the horizon. These situations are recognized by adding a small letter to the master horizon symbol. Thus the Ap horizon has been altered by plowing, and its properties may be quite different from the properties of an A1 or an A2 in an unplowed soil.

Although plowing can only alter the surface, other processes may affect more than one horizon in the same profile. For that reason, we will define the processes and the effects associated with each lower case letter that may occur, and indicate the kinds of horizons where these processes are most likely to be found. As you study the soil profile, always be on the alert for characteristics that indicate these special kinds of horizons, and use the correct symbols to name those horizons.

ca - The horizon has an accumulation of free lime (calcium carbonate) over and above the amount of lime in the original parent material. In relatively dry climates, natural precipitation may be enough to leach only the A and upper part of the B horizon. Carbonates removed from the upper soil are carried downward and redeposited in lower horizons. Evidence of this process is white streaks or nodules that bubble violently when a drop of hydrochloric acid is placed on them. Horizons subject to this kind of alteration include the B2, the B3, and the C.

g - The horizon is gleyed. Gleying is the intense reduction of iron associated with long periods of saturation with stagnant water. Gleyed horizons are usually gray, but may be bluish-gray or black. They may or may not be mottled. Gleyed horizons are generally found only in poorly drained or very poorly drained soils. The gleying process may affect any major kind of A, B, or C horizon.

ir - The soil has a spodic horizon. This is a B horizon that forms by joint translocation of iron, aluminum, and organic matter our of the A and into the B. Spodic horizons may be dark brown or bright yellowish- or reddish-brown, but the color usually fades with depth. Often a B2ir lies immediately beneath a prominent white A2 horizon. The thickness of both the A2 and the B2ir varies from a few centimeters each to over 20 centimeters each. Sometimes the B2 is cemented to form a hardpan. In Oregon, spodic horizons are found only in some of the sandy coastal soils and in a few high-elevation mountainous soils. Spodic character is usually restricted to B2 horizons.

t - The soil has a textural B, or argillic horizon. In many soils, water moving downward through the soil carries some very fine clay particles with it. When the soil dries, these clay particles are deposited as coatings on soil aggregates and in soil pores. Repeated leaching and drying over hundreds of years causes these coatings, or clay skins, to thicken and have a waxy appearance. Thus the argillic horizon has both an increase in clay as compared to the horizons above and below, and evidence of clay movement in the form of clay skins. Structure in the Bt is often blocky or prismatic and quite distinct. Only B1, B2 and B3 horizons may have the characteristics of an argillic horizon.

x - The soil has the characteristics of a fragipan (see Bx). In addition to the Bx, however, these properties may also occur in the C.

SUBDIVISIONS OF MAJOR HORIZONS

Sometimes one or two of the major horizons in a soil profile are so thick that they need to be subdivided. The bases for subdivisions are most often relatively small changes in texture, color, or structure. In A and B horizons, the vertical sequence of subdivisions of a master horizon is indicated by a second arabic numeral. In C horizons, vertical subdivisions are indicated by a single arabic numeral, and arabic numbers have no other connotations in C horizons than to indicate vertical sequence. Examples of some vertical sequences within major horizons are shown below.

A11 - A12 (read A-one-one, A-one-two; not A-eleven)

A21 - A22
Ap1 - Ap2
B21t - B22t - B23t (read B-two-one-t, etc.).
B31 - B32
C1 - C2 - C3
C1x - C2x

LITHOLOGIC DISCONTINUITIES

Soils that are developed in relatively homogeneous parent materials are assigned horizon names according to the conventions described above. Many soils, however, have developed in more than one geologic material. One common situation occurs in river floodplains where layers of silty, sandy, or gravelly sediments may alternate in rapid succession. Another situation occurs when landslides or other mass movements on hillslopes emplace a new soil material on top of a pre-existing one lower on the slope. Still another occurs when windblown silts (loess) or volcanic ash are deposited on top of weathered bedrock.

In any of these cases, Roman numerals are used to indicate that a soil horizon has formed in a geologic material different from the one above. For example, a soil developed in silt loam over gravel might have an A1-A3-B2-IIB3-IIC horizon sequence. The Roman numeral I is never used, as it is understood to apply to the uppermost material. Some soils have formed in a series of several contrasting

layers, and for these Roman numerals are used consecutively for as many layers as are present. Note that the Roman numeral always precedes the master horizon designation, and that it may be used with any kind of A, B, or C horizon.

TYPICAL HORIZON SEQUENCES

To illustrate various ways in which horizons are defined, several soil series are listed below, followed by the sequence of horizons in a typical profile of each soil. Nearly all geographic areas of Oregon are represented on this list.

Alicel	Ap-A12-B1-B2-IIC
Bandon	02-A2-B21ir-B22ir-B23ir-B24ir-C
Brenner	Ap-A12-B21g-B22g-B3g-Cg
Carney	A11-A12-A3-C1-IIR
Cascade	A1-B21-B22-IIBx1-IIBx2-IIBx3
Dayton	Ap-A2-IIB2t-IIB3t-IIIC
Deschutes	A1-B1-B2-IIC-IIIR
Fordney	Ap-C1-C2
Gem	A11-A12-B1t-B21t-B22t-B31t-B32tca-R
Hoopal	A11-A12-B2-C1casim-C2
Josephine	01-A1-B1-B21t-B22t-B23t-C1-C2r
Malabon	Ap-A3-B21t-B22t-B3t-IIC
Nehalem	Ap-A12-B2-C
Nyssa	Ap-B2-C1casi-C2casim-C3casim
Oakland	A11-A12-B21t-B22t-B23t-B3t-Cr
Quincy	C1-C2
Ritzville	Ap-B1-B2-C1ca-C2-C3
Salem	Ap-B2t-B3t-IIC
Simas	A1-IIB21t-IIB22t-IIB3ca-IICca
Walla Walla	Ap-A12-B1-B2-C1ca-C2ca

HINTS FOR LOCATING BOUNDARIES BETWEEN HORIZONS

The most useful thing you can do to help yourself find and name soil horizons is to prepare a good exposure of the soil profile. Either a good pit or a road cut will do, but in either case you should clean up the face of the vertical cut. Use your knife to pick off any soil that may have sloughed off from the surface or that was smeared by a shovel or a backhoe. After you have a good, fresh surface, then try each of the following techniques.

1. Look for color changes. Where there is an obvious color change there is also a horizon change. Color

alone, however, is not sufficient to separate all horizons. Several soils in Oregon have nearly uniform colors extending all the way through the B and into the C.

2. Take a knife and gently poke the soil every few centimeters from the surface down to the lower part of the pit. Often you can "feel" the firmer consistence of subsoils and restrictive layers. You may even be able to locate a contact between B and C this way.

3. Starting at the top, make a quick textural determination with your fingers every 5 to 10 centimeters. If there is a marked increase in clay from A to B, you should detect it this way. Similarly a decrease in clay from B to C should be evident.

4. With your knife, remove a handful of soil from the upper 10 centimeters of soil. Carefully break it apart and observe the size, shape, and strength of structural aggregates. Repeat this process every 10 to 15 centimeters down through the profile. Structural changes may be a good clue to boundaries between horizons and to the presence of transition horizons.

5. Each time you locate a tentative boundary, mark it with a nail, twig, or some other convenient marker. As you consider more and more characteristics you may want to adjust some of the boundaries up or down.

6. When you have settled on an initial set of horizon boundaries, start looking more carefully at the color, texture, structure, pores, clay skins, etc. of each horizon. With a complete set of information, you may wish to make a final adjustment in your horizon boundaries.

CHAPTER 3. PROPERTIES OF SOIL HORIZONS

Once individual horizons have been recognized, each one must be fully characterized so that we can better read and understand the book of soil. Both field and laboratory properties are necessary to fully understand soil behavior, but we will limit our discussion here to the more readily observable field characteristics.

SOIL COLOR

Soil colors are usually associated with specific characteristics of the soil environment that are significant to plant growth. Important kinds of soil colors are listed below, with a brief statement about their cause and significance. In most soils, the color changes depending on whether the soil is moist or dry. Moist colors are usually darker than dry colors. We can always moisten a dry soil, but it may take a long time for a moist soil to dry out. Therefore, the colors described below, and the ones you should judge, refer to the moist color of the soil.

The technical jargon of soil science utilizes a more quantitative method of describing soil colors. This method is discussed briefly at the end of this section. To provide a standard reference, however, Munsell color notations included in each of the color classes below are given in parentheses.

Very Dark Brown or Black - These colors are caused by accumulation of decomposed organic matter; they are most characteristic of A1 horizons. Usually the darker the color, the more the organic matter, hence the more fertile and productive the soil. Some soils, however, may have deep black A horizons because of poor soil drainage, which limits aeration and retards organic matter decomposition. Some other soils high in shrink-swell clays may be nearly black throughout because repeated churning and self-mulching has mixed organic matter throughout the entire depth of shrink-swell activity. (2/0, 2/1, 2/2, 3/0, 3/1, 3/2 in all hues.)

Light Brown, Brown, Yellowish Brown - These colors are caused by iron in the ferric (+3) or oxidized state. In soil horizons having this color, almost all the grains of soil (the primary particles) are coated with iron oxide, which is chemically the same as rust on an iron gate. It is the cumulative effect of these iron oxide coatings that imparts brownish colors to soils. Since oxygen is required, the color indicates good soil aeration. This implies that soil drainage is good or moderately good, and that the brown horizon is rarely saturated for more than very short periods of time. (3/3, 3/4, 4/2, 4/3, 4/4, 4/6, 5/2, 5/3, 5/4, 5/6, 5/8, 6/2, 6/3, 6/4, 6/6, 6/8 in hues of 7.5 YR, 10YR, 2.5Y, 5Y.)

Red, Reddish Brown - Red colors are also caused by iron oxide coatings, but of slightly different chemical composition. Red colors are usually associated with older, more highly weathered soils, and therefore suggest that the soil is more highly leached, more acid, and less fertile than comparable soils with brown colors. Like the brown colors, red colors imply good aeration and good soil drainage. (Same values/chromas as brown in hues of 5YR, 2.5YR, 10R.)

Gray, White - The true color of most mineral grains in soil (quartz, feldspars) is light gray. This color is apparent when iron oxide coatings are stripped from mineral grains. In many soils, gray colors are the result of prolonged wetness. The absence of oxygen in a saturated horizon allows the iron to change to the ferrous (+2) or reduced state. Ferrous iron is much more soluble than ferric iron, and is relatively easily removed from particle surfaces. As water moves through the soil it carries away the ferrous iron, leaving a horizon whose color is that of the true mineral colors. Thus most gray soils are poorly drained soils. White colors can occur in well drained soils, however, especially in sandy soils with pine or spruce trees growing on them. (4/0, 4/1, 5/0, 5/1, 6/0, 6/1, 7/0, 7/1, 7/2, 8/0, 8/1, 8/2 in all hues.)

The more technical method of soil color description utilizes Munsell color notations. These involve symbols like 10YR 4/3 in which the first part (10YR) designates a color hue, or spectral wave length. The numerator of the fraction is called the value; it is an index of the amount of incident light reflected back to your eye. The denominator is called the chroma, and it is an index of the amount

of dilution with white light. The Munsell Color Company makes small color chips that correspond with each combination of hue, value, and chroma. Chips of those colors that are most frequently found in soils are arranged in special books of soil color charts. To determine soil color in the field, one simply matches up the color of a soil aggregate with a chip of the same color. The symbol for that chip is then recorded. Series descriptions of Oregon soils, published either in soil survey reports or as single-sheet official descriptions, use this more precise method of evaluating soil colors.

MOTTLING

Some soil horizons exhibit a variegated pattern of colors, in which case the soil is said to be mottled. Mottles may occur either as splotches of reddish-brown color in a gray matrix, or as gray spots in a brown matrix. In either case, mottles are usually the result of alternating periods of reduction and oxidation caused by seasonally fluctuating water tables. When the soil is wet the iron is reduced, and it is mobile. As a water table recedes and oxygen enters the soil, the iron it contacts quickly re-oxidizes and precipitates. This usually occurs first along root channels or large pores. The result is a soil in which iron is removed from some areas, leaving them gray, and is concentrated in others, making them yellowish-brown. Mottling patterns in soils are the chief criteria for placing soils in drainage classes (see Chapter 4). The presence of mottles, even in a dry soil, indicates that at some other time of year the soil is likely to be saturated, at least to the level of the mottles.

Mottle patterns in soils are described by four parameters: abundance, size, contrast, and color.

Abundance - the percent of exposed surface area occupied by mottles. Classes of abundance are:

Few - less than 2% of exposed surface.
Common - 2 to 20% of exposed surface.
Many - more than 20% of exposed surface.

Size - the approximate diameter of individual mottles. Size classes are:

Fine - diameter less than 5 mm.
Medium - diameter of 5 to 15 mm.
Coarse - diameter more than 15 mm.

Contrast - the relative difference between the mottle color and the matrix color. Classes of contrast are:

Faint - mottles evident only upon close scrutiny. Mottle color and matrix color are very nearly the same.

Distinct - mottles are readily seen though not striking. Mottle color and matrix color are different, though not widely so.

Prominent - mottles are so conspicuous that they are the outstanding visible feature of the horizon. Mottle color and matrix color are widely different.

Color - Mottle colors are described in the same way as colors of any horizon. The most common mottle colors are yellowish-brown, dark reddish-brown, and gray.

Two warnings about interpretation of mottling are necessary. Although we tend to interpret mottles in terms of drainage conditions, that is not always the case. Chemical weathering of the primary minerals in parent rocks can also produce variegated color patterns. To the untrained observer, these patterns are easy to misinterpret as drainage mottles, even though the soil may be quite well-drained. The key is to study other features of the soil and the landscape very carefully. If the soil occurs on concave footslopes or in other low-lying positions, where periodic water tables could reasonably be expected, then the mottles are probably drainage mottles. Or if the soil has a claypan or fragipan, it would be normal to find drainage mottles in and above soil restrictive layers due to the perching of water. Soils on convex uplands or on dissected, rolling terraces, however, would be expected to be well drained, unless a restrictive layer in the soil profile is present. Especially where bedrock occurs within 150 cm of the surface, variegated colors are more likely to be the result of parent material weathering than of wetness. Evidence of original rock structure in variegated horizons provides an additional clue that such color patterns are not due to wetness.

The second warning concerns coatings on soil aggregates. Often the exterior surface of a structural unit, particularly in the B horizon, has a darker color than the interior of the unit. Coatings of clay, organic matter, and moisture all contribute to this effect. The point is, these coatings should not be interpreted as mottles. To determine the true color--or colors--of a soil, a structural ped should be broken open, and both matrix and mottle colors determined from a freshly exposed interior surface.

TEXTURE

Texture is one of the most important properties of soils because many inferences about soil behavior can be made simply by knowing the texture. Texture influences the ease with which soil can be worked, the amount of air and water it will hold, rates at which water can enter and move through the soil, and the ease of root penetration and expansion. Plant food supplies may be indicated by texture, since very small silt and clay particles usually provide more available minerals or plant nutrients than coarser sand.

Texture refers to the particle size distribution of the soil. There are two broad classes of particle sizes in soils: fine earth and coarse fragments. Fine earth includes all particles smaller than 2 mm in diameter. This is the fraction that passes through a No. 10 sieve. Coarse fragments include gravel and cobbles up to 25 cm in diameter. Rock fragments larger than 25 cm are called stones and boulders, and they are not considered part of the soil per se. They are considered as site characteristics, however, and will be discussed in more detail in Chapter 5.

Determination of names of textural classes requires separate evaluations of the fine earth and the coarse fragments. Then the two are combined to form names like silt loam or gravelly sandy loam or very cobbly clay loam. The steps involved in each determination are given in the sections that follow.

Texture of the Fine Earth

Fine earth includes three classes of particle size, or separates: sand, silt, and clay. Sand particles range in size from 2 mm to .05 mm. They are large enough to see each sand grain with the naked eye. They feel gritty. Silt particles range in size from .05 to .002 mm. You cannot see them without a hand lens or microscope. Silt has a smooth feeling, like flour or corn starch. It is not sticky. Clay particles are less than .002 mm in size. They can be seen only with very high-powered microscopes, and are usually flat, or plate-shaped. Clay feels sticky, and it can be molded into ribbons or wires.

Textural names reflect the amounts of sand, silt, and clay in a soil. These names are best shown on a textural triangle (Figure 1). A soil with dominantly a single particle size would lie near the corresponding corner of the triangle.

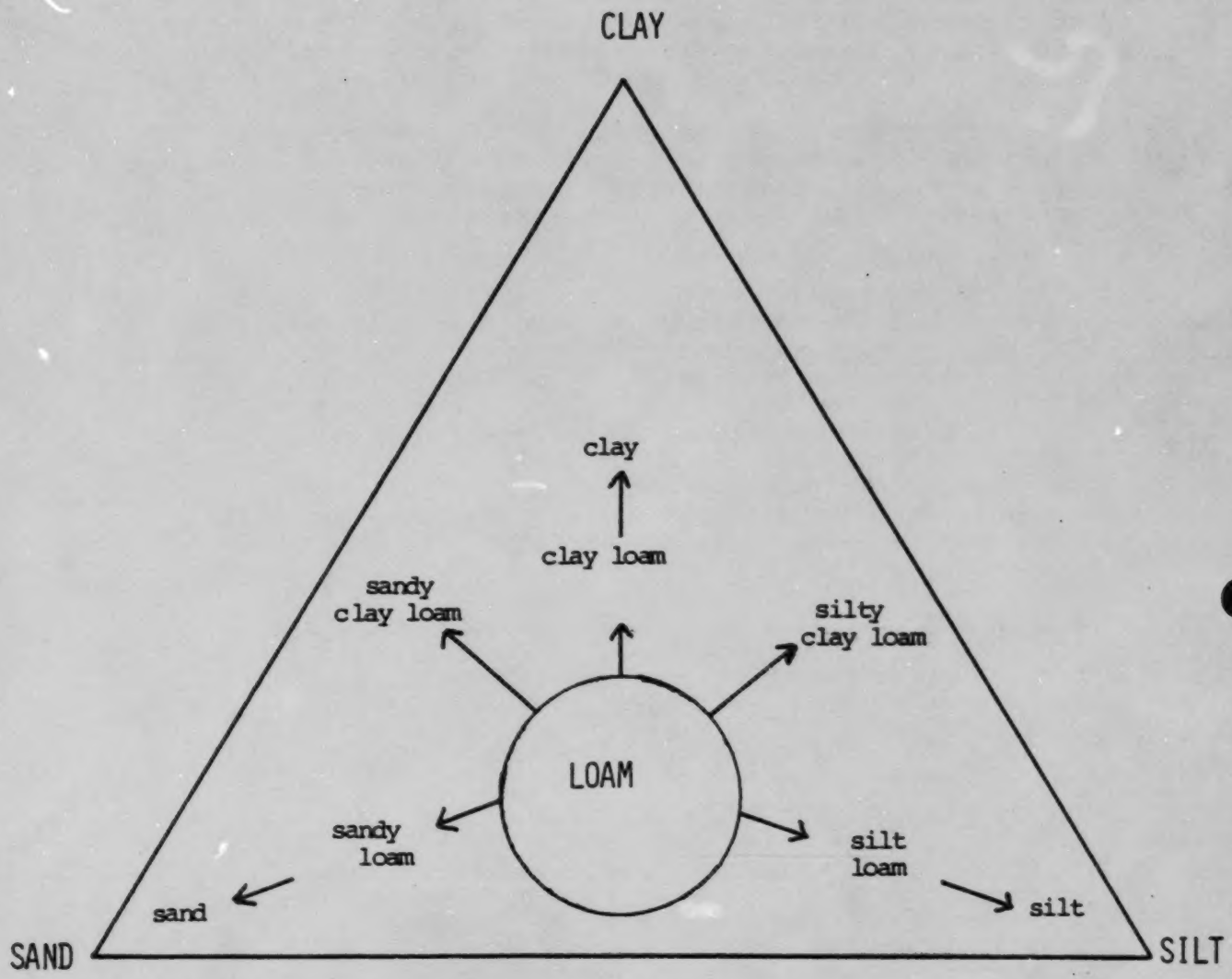

Figure 1. Generalized Textural Triangle

A soil with a balanced mixture of sand, silt, and clay would lie near the center of the triangle. It is called loam. Soils that are basically loamy, but have higher clay contents, are clay loams. If silt predominates, the soil is a silt loam. Study the triangle and see how names of soil textures are modified from loams according to the increasing influence of one or two particle sizes.

Field estimates of the textural class of a soil sample can be made by moistening the soil and kneading it until aggregates are broken apart, then squeezing it between thumb and forefinger. Large pebbles or gravels should be removed as the sample is worked. As you work the sample, remember that sand gives a gritty feel, silt feels smooth or floury, and clay is slick, sometimes sticky, and can be molded into a ribbon. Steps in the procedure are as follows:

1. Fill the palm of your hand with dry soil.

2. Moisten the soil enough so that it sticks together and can be worked with the fingers. DON'T SATURATE IT TO RUNNY MUD.

3. Continue working the soil and removing pebbles, until all structural aggregates are broken down. You may need a little more water.

4. Push the sample upward between thumb and index finger to try to make a ribbon. The length of the ribbon you can make is an indicator of the clay content.

5. As you work the sample, try to estimate the percentages of sand, silt, and clay in the sample. In particular, always ask yourself the following three questions:

   a) Does the sample contain more or less than 50% sand?
      - If more, sandiness will be the dominant feature. The sample will feel very gritty. All textural names will contain the word sandy.
      - If less, go to question (b).

   b) Does the soil contain more or less than 20% sand?
      - If more, the sample is noticeably gritty, though sand doesn't dominate. Textures of loam and clay loam are most likely, although some silt loams and clays may have more than 20% sand.

- If less, the sample is definitely smooth and/or sticky. The only textures possible are silt loam, silty clay loam, silty clay, and clay.

c) Does the sample contain more or less than 27% clay?
- If less, then you can only form a short, broken ribbon by squeezing between your thumb and forefinger. Textures of silt loam, loam, or sandy loam are most likely.
- If more, then you should be able to form a ribbon more than 3 cm in length. Go to question (d).

d) Does the sample contain more or less than 40% clay?
- If less, you can only form a ribbon about 3 to 6 cm long. The only textures possible are silty clay loam, clay loam, and sandy clay loam.

- If more, you should be able to form a ribbon 6 to 18 cm long. The texture is most likely clay. Silty clay and sandy clay are possible, but they are rare.

These four percentages are key points on the textural triangle (Figure 2), which is the official basis for designating names for textural classes of fine earth. As additional guides, the charts below and the clues to the feel of each textural class should help you to zero in on the right texture.

A. More than 50% sand

<20% clay - sand, loamy sand, sandy loam
20-35% clay - sandy clay loam

>35% clay - sandy clay

B. 20 to 50% sand

<27% clay - loam, some silt loams
27-40% clay - clay loam
>40% clay - clay

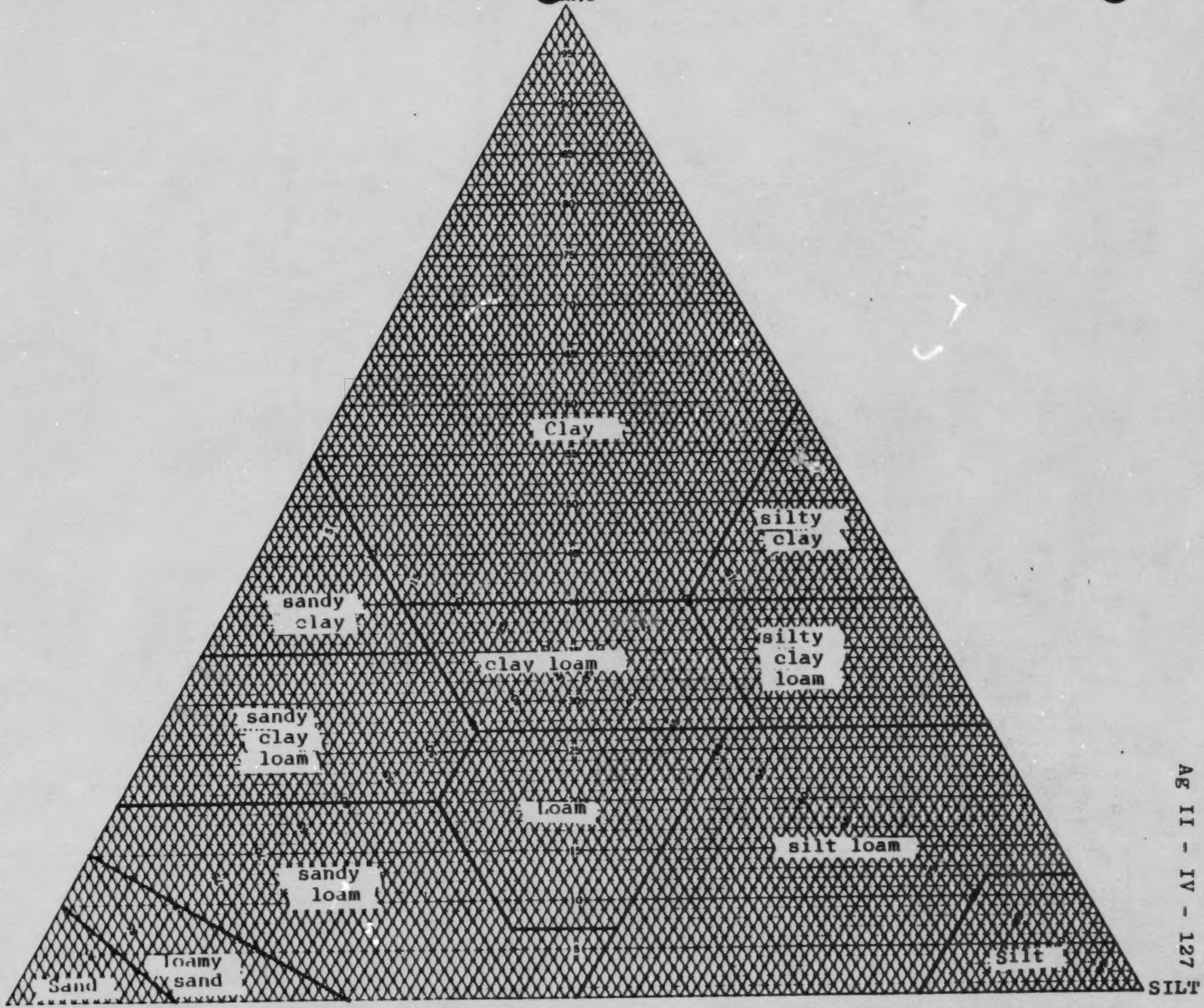

Figure 2. Official Textural Triangle

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C. Less than 20% sand

<27% clay - silt loam
27-40% clay - silty clay loam
>40% clay - silty clay, clay

Clues to the feel of each textural class are:

SAND
-moist sample collapses after squeezing
-hands don't get dirty working the sample

LOAMY SAND
-sample has very little body
-moist soil barely stays together after squeezing
-just enough silt and clay to dirty your hands

SANDY LOAM
-sand dominates noticeably
-enough silt and clay to give the sample body
-moist soil stays together after squeezing
-hardly forms any ribbon at all

SANDY CLAY LOAM
-feels gritty and sticky
-forms ribbon 3 to 5 cm long

SANDY CLAY
-feels definitely sandy
-forms ribbon 5 to 8 cm long
-a very rare texture in Oregon

LOAM
-sand noticeably present, but doesn't dominate
-sample works easily between thumb and fingers
-contains enough silt and clay to give sample good body
-sample only forms short, broken ribbons

SILT LOAM
-feels smooth, like flour or corn starch
-tends to be non-sticky
-only forms short, broken ribbons

CLAY LOAM
-noticeable grittiness, but sand doesn't dominate
-noticeable stickiness and plasticity
-noticeable resistance to working between thumb and fingers
-forms ribbons 3 to 6 cm long

SILTY CLAY LOAM
- -feels smooth and sticky
- -contains very little sand
- -forms ribbons 3 to 6 cm long

CLAY and SILTY CLAY
- -dry sample absorbs a lot of water before it is moist enough to work
- -sample very tough to work between thumb and finger
- -forms ribbons 6 to 10 cm long

Coarse Fragment Adjustments

Soil textural names based on the fine earth must be modified if the soil contains a significant amount of coarse fragments. While there are several possible kinds of coarse fragments, in Oregon soils only two are likely to be encountered: gravel and cobbles. Gravel refers to rounded rock fragments with a diameter between 2 mm and 7.5 cm. Cobbles are rounded or subrounded, and have diameters of 7.5 to 25 cm.

The extent of modification of a textural name depends on the volume of the soil mass occupied by coarse fragments. This can be estimated by the percentage of the exposed area of the profile surface that consists of coarse fragments. Having determined both the % by volume and the dominant size of coarse fragments, the correct modifier can be taken from the key below. In the event that a soil contains both gravel and cobbles, convention requires that at least 60% of the coarse fragments must be gravel to use the gravelly term. If more than 40% of the coarse fragments are cobbles, use the cobbly term.

	SIZE OF COARSE FRAGMENT	
% by volume	2 mm. - 7.5 cm	7.5 - 25 cm
15 - 35	gravelly	cobbly
35 - 60	very gravelly	very cobbly
>60	extremely gravelly	extremely cobbly

SOIL STRUCTURE

Structure is formed by the aggregation of primary soil particles into larger units called peds. Structure is important because it creates relatively large pores, which

allow for good aeration, good permeability and soil drainage, and ease of plant root penetration. Soils with poor structure tend to be more massive and have poorer aeration and drainage, and are less favorable for plant growth.

Structure is described in terms of the shape, size, and grade of the peds. These are discussed briefly below.

Shape and Size

GRANULAR - roughly spherical, like grape nuts, usually 1-10 mm in diameter. Most common in A horizons, where plant roots, microorganisms, and sticky products of organic matter decomposition bind primary particles into granular aggregates.

PLATY - Flat peds that lie horizontally in the soil. Most are less than 2 cm thick. Platy structure is not common in Western Oregon soils, but it can occur in a plow pan at the base of an Ap or in soil horizons where water is forced to move laterally. Many of the soils in low-rainfall regions (<12 inches) of eastern Oregon do have platy structure in the A1 horizon.

BLOCKY - roughly equidimensional, with more or less flat surfaces. If edges and corners remain sharp, we call it angular blocky; if they are rounded, we call it subangular blocky. Sizes commonly range from 5-50 mm across. Blocky structures are typical of B horizons, especially Bt horizons, and their formation is due in part to repeated expansion and contraction of clay minerals.

PRISMATIC - larger, vertically elongated blocks, often with 5 sides. Sizes are commonly 10-100 mm across. Prismatic structures occur in the lower parts of B horizons and in C horizons.

MASSIVE - compact, coherent soil not separated into peds of any kind. Massive structures in fine textured soils usually have very small pores, slow permeability, and poor aeration.

SINGLE GRAIN - In some sandy soils, every grain acts independently and there is no binding agent to hold the grains together into aggregates. This usually occurs only in the larger sand sizes and when there is virtually no silt or clay present. Permeability is rapid, but fertility and water-holding capacity are low.

Grade--Structural grade is the degree of expression of soil structure. There are two attributes of grade: 1) how well the entire soil mass is subdivided into distinct and recognizable aggregates; and 2) how strong the grains in individual aggregates are held together to give stability to the peds. The classes of structural grade are described below.

STRONG - the soil mass is well divided into distinct and easily recognizable peds. Structure is evident on the face of a soil pit. A handful of soil readily breaks into distinct peds with only very gentle pressure. Individual peds are very stable and resist further breakdown.

MODERATE - structure may or may not be evident in a pit face, but can be easily detected by gently breaking apart a mass of soil held in the hands. Some grains of soil may not be part of any aggregate, or easily slough off larger aggregates. Peds are stable against weak forces but may break down under stronger pressure.

WEAK - peds are difficult to detect, even when breaking soil apart in the hands. Many grains may not be part of any aggregate. Peds easily break down when small forces are applied.

STRUCTURELESS - the grade applied to massive and single grain soils.

Compound Structure - Some soil horizons have large structural aggregates which can be further subdivided into smaller aggregates of a different shape. Examples are blocks which break into plates, or prisms which break into blocks. Technical soil descriptions would include both situations. For soil judging, if one shape has a stronger grade, check that one. If both have the same grade, mark the smaller one.

SOIL CONSISTENCE

Consistence has to do with the strength of the soil mass. It may be defined as the resistance to deformation or rupture when pressure is applied. When the resistance is low, the soil is easily manipulated. Energy requirements for plowing or tillage are low, and plant seedlings can easily push their way up through the soil. When the resistance is high, the soil is much more difficult to work.

Cloddy seedbeds are more likely, and seedling emergence is more difficult. Consistence is also related to the trafficability of a soil and its ability to support structural loads.

Consistence is determined by taking a small handfull-sized mass of soil and applying pressure between the thumb and fingers. Since the resistance to deformation is very much affected by moisture content, consistence is determined at three different moisture levels: moist, dry, and wet. In western Oregon, moist consistence is the one most frequently determined. In eastern Oregon, it is dry consistence. Wet consistence can be determined for any sample with the proper addition of moisture.

Moist Consistence

Moist consistence is determined when the soil is at, or a little dryer than, field capacity. Usually when soil is found to be moist--but not saturated--in the field, we will make a determination of consistence and call it moist conditions. Important consistence classes, with guides for their determination, are listed below.

LOOSE - the soil does not stick together in a mass.

FRIABLE - soil material crushes easily under gentle pressure between thumb and forefinger.

FIRM - soil can be crushed between thumb and forefinger, but considerable pressure is required to overcome natural resistance.

EXTREMELY FIRM - soil cannot be crushed between thumb and forefinger, and can only be broken apart bit by bit.

Dry Consistence

This is determined for soils that are air dry, even in the field. While it may be described for any soil, it is usually the preferred system for eastern Oregon soils. Important classes, with guides for identification, are given below.

LOOSE - the soil does not stick together in a mass.

SLIGHTLY HARD - the soil crushes easily under gentle pressure between thumb and forefinger.

HARD - the soil is barely crushable between thumb and forefinger but can be broken with the hands without much difficulty.

EXTREMELY HARD - the soil is so resistant to deformation that it cannot be broken in the hands.

Wet Consistence

When the soil is a little wetter than field capacity, two attributes of soil behavior are measured: stickiness and plasticity. Stickiness is evaluated by squeezing wet soil between your thumb and fingers, then slowly pulling your thumb away. The stickier the soil, the more it will stretch and pull apart before breaking, leaving soil adhering to both thumb and fingers. The relative degree of stickiness is expressed using the terms nonsticky, slightly sticky, sticky, and very sticky.

Plasticity measures the extent to which the soil can be molded and can retain a shape after pressure is removed. It is determined by rolling the soil between the hands to form a thin wire. The longer and thinner the wire formed, and the more resistant it is to whipping back and forth, the more plastic the soil. Terms used to describe relative plasticity are nonplastic, slightly plastic, plastic, and very plastic.

HORIZON BOUNDARIES

The gradation from one horizon to another can vary both in distinctness and topography. Some boundaries are very sharp, while others merge very gradually into the horizon below. The nature of the boundary may provide clues to soil development and to certain aspects of soil behavior. An abrupt boundary may indicate a sudden change to another kind of material, either geologic or formed by soil development. Such a change may limit root penetration, or it may signal a different rate of water movement through the soil. Gradual boundaries may occur in very young soils, or in deep, highly weathered old soils.

Distinctness

There are four classes of horizon boundary distinctness. Criteria for each are given below.

ABRUPT - the boundary is less than 2.5 cm wide.

CLEAR - the boundary is 2.5 to 6 cm wide.

GRADUAL - the boundary is 6 to 12.5 cm wide.

DIFFUSE - the boundary is more than 12.5 cm wide.

Topography

The shape of horizon boundaries may also be described. Evaluation of this characteristic, however, requires careful examination all along a pit face or road cut to be sure that the true relationships between horizons have been discovered. The classes of boundary topography are:

SMOOTH - nearly a plane.

WAVY - shallow pockets are wider than they are deep.

IRREGULAR - pockets are deeper than their width.

BROKEN - parts of the horizon are unconnected with other parts.

CHAPTER 4. PROPERTIES OF THE WHOLE SOIL

The kind and sequence of horizons in a soil, together with the properties of each horizon, provide the record that we must read to glean even more information about the soil. Most of the properties of the whole soil are really inferences. Some data, either from field tests or from laboratory analyses, may be available to help make the interpretation. But in general, we synthesize in our mind all the effects of things like texture, structure and organic matter on drainage, or permeability, or water-holding capacity, then make the best professional judgment we can. So in the following discussion of the important properties of the whole soil, look for the clues to reaching the proper inference that are provided by the properties of the horizons themselves. Remember, though, that it is virtually impossible to write interpretation guides that apply equally to each and every soil in Oregon. For that reason, the information in the sections that follow should be taken as guides, but not as absolute determinants of the characteristics involved.

EFFECTIVE DEPTH OF ROOTING

Many plants can and do extend roots to depths well beyond a meter, provided there is no physical barrier to root growth. Soils that allow deep rooting are potentially very productive, for they allow plants to exploit the greatest possible volume of soil in search of water and nutrients. Soils that have restricted rooting depths are potentially droughtier and may require more fertilizers.

The effective depth of rooting will be taken as greater than 150 cm if there are no limitations. Rooting is restricted in soils that have fragipans, duripans, claypans, bedrock, or layers of very coarse textures. You will have noted the presence of a fragipan by the symbol Bx. The effective depth of rooting is the distance from the ground surface to the top of the fragipan. Similarly, a duripan is the horizon designated Ccasim. The top of the duripan is also the limit of rooting depth. A claypan may be a B2, B2t, or C horizon. In any case, it has a very high clay content, at best weak structure when moist (many are massive, but some also crack considerably as the clays shrink upon drying), and an abrupt

boundary separates it from the siltier horizon above. The top of a claypan is also the limit of effective root depth. Some soils have strata of gravelly sand or even coarser materials. They store so little water and nutrients that they are not effective for root growth. Thus the effective depth of rooting stops at the top of such coarse layers. Hard bedrock (R horizon) is an obvious limit to root depth. Other horizons that are massive or dense may also limit the effective depth of rooting, especially if they are deep in the soil.

Soils that are wet for long periods of time may also limit root growth. However, there is no way to tell exactly how far roots can penetrate in such soils. In general, soils that are gleyed throughout the B and C horizons will not have roots penetrating beyond the upper portion of the gleyed material. Permanent water tables, of course, may be taken as an absolute limit to the depth of rooting.

Further clues to the effective depth of rooting may be given by the roots themselves. If roots are clearly visible and easy to find throughout the soil, then there is no limit to the effective depth. Sometimes, though, only shallow-rooted plants may be growing on the soil, even though the effective depth is unlimited. So an absence of roots doesn't necessarily mean there is a root depth limitation. On the other hand, some plants may be able to send a few very fine roots partly into a fragipan or a claypan. Most of the volume of those horizons is still ineffective in supporting plant growth, though. So if you find one tiny root down at the bottom of the profile, that doesn't necessarily mean the effective depth is unlimited. Another clue may be the pattern of root growth. Dduripans, fragipans, and some claypans may be so impenetrable that plant roots start growing horizontally along the top of them. If you find such a horizontal root mat, it's pretty good evidence of not only the effective depth but also the position of the horizon boundary itself.

AVAILABLE WATER HOLDING CAPACITY

As far as a plant is concerned, there are three important classes of water in the soil. Gravitational water is contained in large pores, when the soil is saturated. It drains away quickly as soon as the water table drops or it stops raining. Plants cannot make any effective use of

gravitational water. Available water is retained in smaller soil pores against the force of gravity. Plants, however, can remove this water and utilize it. There is a limit, though, to the amount of energy that plants can exert to remove water. Beyond this limit there is still water in the soil--sometimes a lot of water--but it is held so tightly in the soil pores that it cannot be removed. This water is unavailable to plants, and they will die even though the soil is still moist.

The amount of available water a soil can provide depends mainly on its texture, but structure and organic matter can modify the influence of texture. Texture, structure, and organic matter all interact to control the number, and more importantly, the size of soil pores. Soils dominated by very large pores, as in gravelly and sandy soils, cannot retain much water against the force of gravity. Their available water holding capacity is low. Soils dominated by very tiny pores, as in clays and silty clays, hold water so tightly that much of it is not available. Soils with medium textures, like loam, clay loam, and silt loam, have an optimum pore size distribution and hold the maximum amount of available water.

Good soil structure generally improves air-water relations and increases the available water holding capacity. Thus a clay soil that has strong structure will have more available water than a massive clay or one with weak structure. On the other hand, a massive silt loam in a fragipan will have much less available water than a silt loam B2t that has moderate subangular blocky structure.

Organic matter exerts its influence mainly by promoting good structure, especially in A1 horizons. But organic matter itself is very porous and contributes to the total available water supply.

Available water holding capacity (AWHC) is measured in terms of the number of cm of water that the entire soil can hold, down to the depth of effective rooting. Think of the soil as a giant sponge, which we could squeeze to remove the available water. If we could catch all that water in a pan, the depth of water in the pan would equal the number of cm of available water stored in the soil. Because each horizon in a soil may have different water-holding capacities, it is customary to express AWHC as cm/cm of depth. Then the amount of water held in each different horizon can be

calculated separately, and the total water holding capacity is found by adding the contribution from each horizon. The following example illustrates the procedure:

Horizon	Thickness	AWHC	Calculations
A1	30 cm	.20 cm/cm	30 cm x .20 cm/cm = 6.0 cm
B1	20 cm	.18 cm/cm	20 cm x .18 cm/cm = 3.6 cm
B2t	40 cm	.15 cm/cm	40 cm x .15 cm/cm = 6.0 cm
B3	30 cm	.10 cm/cm	30 cm x .10 cm/cm = 3.0 cm
R	25 cm	0	25 cm x 0 = 0
			TOTAL AWHC = 18.6 cm

In the field then, you must first estimate the cm/cm of AWHC for each horizon by considering the texture and the possible effects of structure and organic matter. Then you note the effective depth of rooting. Then you calculate the amount of water held in each horizon down to the effective depth, or to 150 cm, whichever comes first. Then you add up the parts to arrive at the total. The chart below is a handy guide for estimating AWHC from the textures of the soil.

Texture*	AWHC (cm/cm)
Sand, Loamy sand	.05
Sandy loam, Sandy clay loam	.15
Silt loam, Loam Silty clay loam, Clay loam	.20
Clay, Silty clay	.15

*Figures given are for fine earth only. If the soil contains coarse fragments, the AWHC must be reduced by the same percentage as the coarse fragments occupy. For example, a gravelly loam with 25% gravel (75% fine earth) would have an AWHC of .75 x .20 cm/cm = .15 cm/cm.

The final step in estimating the available water holding capacity of a soil is to place it in one of four general classes, according to the criteria below. With a little experience, you may very well be able to make this evaluation directly without having to grind out all the intermediate calculations.

AWHC Class	Total Available Water in Entire Soil
Very low	less than 7 cm
Low	7-14 cm
Medium	14-20 cm
High	more than 20 cm

INFILTRATION

Infiltration is the rate at which water can enter soil. Like available water holding capacity, it is affected mainly by texture, structure, and organic matter. Infiltration rates are highest in soils that have relatively large pores right at the soil surface. Sandy soils and well-aggregated soils provide this condition. Slow infiltration rates are characteristic of fine-textured soils or soils with poor structure at the surface.

Infiltration is important because it directly affects irrigation, runoff, and erosion. Soils best suited for center pivot irrigation have rapid infiltration rates, because water often must be applied through the outer end of the pivot at rates approaching 2.5 cm per hour. At slower and slower infiltration rates, it takes longer to move water into the soil, and the efficiency of use of irrigation equipment goes down. Also, slow infiltration increases the hazard that applied water--either as rain or as irrigation water--will run off over the surface. This not only increases the erosion hazard, but it also reduces the opportunity to fill up the soil reservoir with available water. This is not a serious problem in western Oregon, but can be a critical matter in low-rainfall regions of eastern Oregon.

Several things can cause the infiltration rate to change over time. In many soils that have silt loam or silty clay loam surface textures, the impact of falling water drops can break down some of the structural aggregates. Particles of silt and clay slake off and clog up the larger pores. The result is a very thin surface crust which has a substantially lower infiltration rate. Maintaining high levels of organic matter helps prevent this situation. Also, natural cracking during the summer, and freezing during the winter, help break up crusts and partially restore the infiltration rate. In western Oregon, soils that are either shallow to bedrock or that have a restrictive claypan or fragipan, may simply fill up with water, like a bathtub. Under these conditions, infiltration may cease for a while regardless of how porous the surface may be.

Infiltration rates can be measured in the field by simulating rainfall and measuring the rate of intake. On this basis, three general classes of infiltration are specified:

RAPID - more than 2 cm of water enter the soil per hour.

MODERATE - water enters at rates of 0.5 to 2.0 cm/hr.

SLOW - water enters at rates less than 0.5 cm/hr.

Without actually measuring infiltration rates, we can estimate them by evaluating the texture and structure of the A1 or Ap horizon. It is not uncommon, however, to find two or more structures within the surface horizon. For example, the uppermost 2 or 3 cm may have a strong granular structure due to the roots of sod-forming crops. The middle of the A may also have good structure, or it may be almost massive if the soil has been puddled by plowing when it was too wet. The lower part of an Ap often has platy structure. To be consistent, judge the infiltration in the middle of the A1 or Ap horizon. Even if the infiltration rate should be higher in the uppermost 2 or 3 cm, the infiltration rate will very quickly be controlled by water movement through the middle of the A1. Judging the center of the horizon will give us a more realistic infiltration rate.

Guide for Estimating Infiltration Rate

	Structural Grade			
Texture	Structureless	Weak	Mod.	Strong
Sand, loamy sand	Rapid	Rapid	Rapid	Rapid
Loam, silt loam, sandy loam	Slow	Mod.	Mod.	Rapid
Silty clay loam, clay loam, sandy clay loam	Slow	Slow	Mod.	Mod.
Clay, silty clay, sandy clay	Slow	Slow	Slow	Mod.

PERMEABILITY

Permeability is the rate at which air or water can flow through a soil. It, too, depends on the pore size distribution in soils, which is related to such things as texture, structure,

density, and porosity. Permeability affects irrigation potential, feasibility of artifical drainage, leaching of salts and fertilizers, and performance of septic tank drainfields. Soils with slow permeability are not as well suited for irrigation, because water in the soil can't move out of the way fast enough for additional water to infiltrate. Soils with slow or very slow permeability are difficult to tile drain, because any one tile line doesn't remove water from much soil beyond that directly over the tile. Tile lines have to be placed very close together in such soils, and that's expensive. Soils with rapid permeability are readily leached, so nitrogen fertilizers should be added as close to the time of actual plant use as possible. These soils also tend to have low water holding capacities. Septic tank drainfields require soils with moderate permeability, for effluent must move away from tiles fast enough to prevent saturation of the soil, but slow enough to ensure adequate biological treatment.

Permeability is difficult to measure in the field, because it can vary considerably from place to place. Variability in the size and configuration of pores, especially large pores like soil cracks, root channels, and animal burrows, can play a large part in field permeability. There is also a laboratory test, called hydraulic conductivity, which measures the rate of flow of water through soil. This test also has weaknesses, because it only measures vertical flow through a very small sample of soil. Nevertheless, the laboratory data have been used to establish 7 classes of soil permeability. These are here condensed into three classes:

SLOW - less than 0.5 cm per hour.

MODERATE - 0.5 to 15 cm per hour.

RAPID - more than 15 cm per hour.

Because of the uncertainty in quantitative measures of permeability, we can do almost as well by making qualitative estimates based on an overall judgment of the combined effects of texture, structure, organic matter, consistence, density, and porosity. A guide for making this determination is given in the chart that follows. Since the permeability of the soil will be controlled by the rate of water flow through the least permeable horizon, that is the one evaluated to specify soil permeability. There are two conditions placed on the determination of this horizon. First, do not consider the surface horizon for the evaluation of permeability. Second, if the soil has a duripan or an R horizon, judge permeability only for the soil above these two restrictive layers.

Guide for Determining Soil Permeability

Texture	Permeability
Sand, loamy sand	Rapid
Sandy loam	Moderate--if porous and low density
Silt loam, loam	Slow--if low porosity, high density
Sandy clay loam	Moderate--if structure is moderate or strong, or soil is friable and porous
Clay loam	
Silty clay loam	Slow--if structure is weak or massive, or soil is compact and dense
Clay	Moderate--if structure is strong
Silty clay	Slow--if structure is weak or moderate
Sandy clay	Very Slow--if soil is dense and massive

WATER EROSION HAZARD

The susceptibility of the soil to erosion by water is an important concern for management of cultivated soils. Erosion not only damages the productivity of the soil, it also causes increased sedimentation in rivers and streams.

Erodibility is related to a number of soil factors. Chief among them are runoff and slope. As both increase, so does the erosion hazard. Because runoff is closely related to infiltration, and infiltration is closely related to texture, erodibility can be judged from a knowledge of the texture and infiltration of the surface horizon and the slope of the soil. Of all the soil textures, the medium textures, especially silt loam, are the most erodible. That's because the size of silt particles is optimum for detachment and transportation by water moving over the soil surface. Sand particles are too big to easily dislodge and move, while clays are so small that they are not easily dislodged.

One other soil factor that affects erosion is soil depth. Soils that are very shallow to restrictive layers like bedrock, fragipans, or claypans are more erodible than deep soils. They hold so little water that excesses quickly begin to run off, prolonging the period of erosion conditions.

Vegetation and climate are not soil factors, but they do influence the erosion hazard. Natural forest provides the best erosion protection, even on very steep slopes, because the 01 and 02 horizons have very high rates of infiltration and permeability. Solid cover crops like pasture and hay also reduce erodibility. They promote rapid infiltration, reduce the velocity of flow across the surface, and tend to bind soil particles together and hold them in place. Forest clear-cuts and clean-tilled row crops tend to increase the erosion hazard. In both cases there is likely to be some break-down of soil structure, so less water infiltrates. Without vegetation there are no roots to hold the soil down, and nothing to slow down the velocity of runoff water.

The effect of climate is felt mainly as the intensity of individual rain storms. The total amount of yearly rainfall is far less important than the intensity of each storm. Many storms are not particularly erosive because the rate of rainfall is less than the soil's infiltration rate. Occasionally, however, it rains so hard that the infiltration rate is exceeded. Runoff starts almost immediately, and the volume of runoff can be large. When this happens, erodible soils not protected by vegetation can lose tremendous volumes of soil. The result can be economic loss to farmers and environmental degradation for all of us.

Because of the many factors that enter into the evaluation of erosion hazard, it is difficult to write a simple guide that will apply to all situations. The guide below attempts to evaluate erosion hazard assuming a bare cover situation. A reasonably good approximation can be obtained from the relationships between slope, surface texture, and infiltration. This is shown in the chart that follows.

Guide for Determining Water Erosion Hazard

Slope	Infiltration	Surface Texture: Silt loam, Loam, Clay loam, Silty clay loam Sandy clay loam	Surface Texture: Clay, Silty clay, Sandy clay, Sandy loam, Loamy Sand, Sand
0-7%	Moderate	Low	Low
	Slow	Moderate	Low
7-12%*	Moderate	Moderate	Low
	Slow	High	Low
12-20%*	Any	High	Moderate
>20%*	Any	Very High	High

*In western Oregon, sloping soils that have a shallow restrictive layer have a higher erosion hazard. For judging purposes, soils on slopes ≥7% that have a restrictive layer within 50 cm of the soil surface will have an erosion hazard one class higher than the one specified in the Guide. For example, a soil with a loam surface texture and moderate infiltration, a slowly permeable layer at 40 cm, and a 10% slope would have a high, rather than a moderate erosion hazard.

WIND EROSION HAZARD

In eastern Oregon climatic conditions favor soil blowing. Wind erosion is costly to agriculture because valuable topsoil is lost. Blowing sand is also abrasive and can seriously damage young crops. Wind erosion is costly to the environment because it reduces air quality and creates a dust nuisance. Road ditches may quickly fill with sediment and require frequent cleaning. Wind erosion can also be costly to human lives. Blowing sand and silt reduce visibility markedly. A few years ago, blowing sand was the direct cause of a multiple vehicle accident on I-84 that resulted in a spectacular fire and the loss of several lives.

Besides a climate that favors strong, steady winds, the major soil factor that affects wind erosion is surface texture. Loam and silt loam soils will blow, but sandy loams and loamy sands are worse. That's because fine sand particles are easily picked up by the wind, but aren't dispersed as widely, and they are more abrasive. To judge

wind erosion hazard, consider first the location in Oregon, then the texture of the surface horizon. As with water erosion, evaluate the soil in the worst possible condition, i.e., with no vegetative cover.

Guide for Determining Wind Erosion Hazard

Location	Texture	Hazard
W. Oregon	Any	None
E. Oregon	Silt loam, Loam	Moderate
	Sandy Loam, Loamy Sand	Severe
	All others	None

INTERNAL SOIL DRAINAGE

Soil drainage refers to the frequency and duration of periods of saturation in the soil. Periodic saturation usually occurs because the soil is close to a water table that fluctuates up and down seasonally. Other factors that affect drainage include landscape position, permeability, restrictive layers, and rainfall.

Soil drainage is important because it affects the environment of plant root growth. Ideally, about half the pores in the soil should contain water; the other half should contain air. When the soil is saturated, plant roots quickly become oxygen-starved, and prolonged saturation kills many plants. Consequently the choice of crop plants is severely limited in poorly drained soils. Wet soils are also cold soils, and early spring growth is retarded because it takes longer for the soil to warm up. Similarly, wet soils cannot be plowed or cultivated as early in the year, so planting dates may have to be set back. Nitrogen fertilizers are not used as efficiently in wet soils, because wetness accelerates loss of nitrogen to the atmosphere. And finally, root rots and other plant diseases are more serious in soils with impeded drainage.

Soils with high water tables are poorly suited for homesites, too. Septic tank drainfields cannot be installed in these soils, because effluent could contaminate groundwater without adequate treatment. No one wants water in the basement of their house, so special precautions must be taken when houses are built on poorly drained soils.

Rarely are we able to observe water tables directly as they fluctuate throughout the year. Instead we make infer-

ences about the frequency and duration of saturation based on the properties of the soil itself. The most important clues are given by color and mottling. Brown, yellow, and red colors are characteristic of well-oxidized soils. These soils are rarely saturated, and when they are, it is for only very short periods of time. Gray or bluish-gray colors reflect intense reduction, which can only be caused by long periods of saturation. Mottles indicate that a soil undergoes repeated cycles of saturation and oxidation. They often represent the effects of temporary water tables that may be perched above slowly permeable layers.

Permeability may be another clue to internal soil drainage. It is not the same as drainage, though. Some sandy soils that have rapid permeability may be poorly drained if they have a permanent high water table. Or a slowly permeable soil may have good drainage if the soil is on a convex upland and has no restrictive layers. Slow permeability, though, does suggest that water added to the surface by rainfall or as runoff from surrounding soils cannot escape quickly by moving through the soil. This situation may indeed be conducive to build-up of at least temporary water tables.

Permeability is especially valuable when combined with evidence of restrictive layers like fragipans or claypans. Because these layers are so slowly permeable, water does tend to build up above them, creating perched water tables. These water tables are temporary, and their presence is usually indicated by mottling just above and in the upper part of the restrictive layer. The closer these layers are to the surface, the more frequent and prolonged the perched water table will be. Conversely, restrictive layers deep in the soil may have little effect on internal drainage, particularly if the soil above them is moderately permeable.

Landscape position provides valuable information on soil drainage. Soils on convex uplands tend to lose water both by runoff and by vertical and lateral movement internally. They are generally well drained. Soils lower on the slope, or in concave footslope positions, tend to receive more water as runoff from surrounding soils than they lose by runoff themselves. They also receive water by seepage from higher soils. Soils in these positions are likely to have water tables close to the surface periodically. They are especially prone to impeded drainage if in addition they contain slowly permeable layers. Soils in low-lying, level or depressional areas may have permanent water tables not

far beneath the surface. Again, slow permeability compounds the problem, although it is not necessary in order for poor drainage conditions to form.

The climatic effect is one of total rainfall. In western Oregon, total rainfall far exceeds the soil capacity to store water. The excess must either run off or move down through the soil to a deep water table, or else the soil will have restricted drainage. In eastern Oregon, the limited amount of rainfall rarely creates this kind of excess. Many of the soils are well drained. Only in some of the basins that have naturally high water tables are there soils with restricted drainage. Often these same soils are salty or alkali soils.

The internal drainage of a soil is expressed as one of 5 drainage classes, as defined below. Because of the importance of color and mottling, these characteristics are used to formulate the guides for placing a soil in a given drainage class. Landscape, permeability, restrictive layers, and climate are all used as supporting evidence. Remember, too, that some soils may have variegated colors or coatings on aggregates that are not related to internal drainage. The drainage classes that we will use are:

Excessively Drained - These soils have sand to sandy loam textures and are often gravelly or cobbly. The permeability is rapid. They have the brownish colors of well oxidized soils, and are not mottled.

Well Drained - These soils may have any texture, though silt loam, silty clay loam, loam, clay loam, and sandy loam are most common. They may have any permeability, though moderate is most common. Soil colors are various shades of yellowish-brown and reddish-brown, all indicating well aerated soil. Although these soils do not have high water tables, the lower part of the soil occasionally may be saturated for a day or two at a time. There are no mottles within 1 meter of the surface, but the soil below 1 meter may have a few gray mottles.

Moderately Well Drained - These soils may have any texture. Permeability is usually slow or moderate. They may have a deep restrictive layer that temporarily perches water. The upper part of the soil is brown, yellowish-brown, or reddish-brown. The soil below 60 cm is

mottled. The mottles may be gray mottles in a brownish matrix, or they may be yellowish-brown mottles in a grayish-brown matrix.

Somewhat Poorly Drained - These soils may have any texture and any permeability. In western Oregon, these soils usually occur in flat or low lying positions that have seasonally high water tables. Some have fragipans or claypans as well, and even a few upland soils that have these restrictive layers are somewhat poorly drained. These soils are rarely saturated to the surface for long periods of time, but they are saturated long enough to cause some graying and mottling of the soil somewhere between 20 and 60 cm.

Somewhat poorly drained soils are not mottled in the Ap or A11 horizon. The second horizon may or may not be mottled, but if it is, the matrix is usually brown, and the mottles are no more than common. A few soils have a gray A2 that contains dark mottles. At increasing depths, the mottling becomes more pronounced.

In eastern Oregon the mottling pattern may not be as easy to detect. Two kinds of somewhat poorly drained soils may occur. In one, black or very dark brown colors may extend throughout the soil. These either have yellowish-brown or reddish-brown mottles below 30 cm, or they have a few grayish mottles throughout starting right below the Ap. In the other, high sodium contents, indicating that water rises toward the surface and evaporates, give the soil pH values greater than 9.0. In both cases, low-lying landscape positions and dark soil colors are indicators of impeded drainage.

Poorly Drained - These soils are saturated at or near the surface for long periods each year. They either occupy low-lying or depressional areas that have permanently high water tables, or they have restrictive layers close to the surface, or both. Any texture or permeability can occur, but fine textures and slow permeabilities are most common.

In western Oregon, poorly drained soils have either mottles or small black concretions right in the Ap or A11. The second horizon is usually mottled also, and common mottling is the norm. In a few soils, black colors due to high organic matter contents may completely mask the mottles in surface horizons. Gleyed horizons

are common in poorly drained soils, but they are not required. The gleyed soil may occur right below the Ap, or it may be a little farther down. It may or may not be mottled.

Poor drainage is harder to evaluate in eastern Oregon. In all cases, prolonged wetness retards organic matter decomposition, so the soils tend to be black or very dark brown throughout. Mottles may be absent or faint, though, and are rarely prominent. Some poorly drained soils have yellowish-brown or reddish-brown mottles in the dark matrix immediately below the Ap or A1. Others are truly gleyed, so that the soil below the A1 is a gray or dark gray that becomes noticeably light gray upon drying. This gleyed soil may or may not be mottled, but if it is, the mottles tend to be darker than the matrix and gray or grayish-brown in color. Landscapes are low-lying to depressional in every case.

CHAPTER 5. SITE CHARACTERISTICS

Soils are more than the horizons that make up their soil profiles. They are also part of the landscape. The position of the soil in the landscape can tell us something about the age of the soil and the kind of geologic materials from which the soil developed. Landscape characteristics affect runoff, erodibility and certain aspects of soil management. Site evaluation, then, is as important a part of soil judging as is the description of the properties of each horizon. There are 5 major site characteristics that should be judged; they are discussed in the following sections.

SITE POSITION

The site position is the landform on which the soil occurs. Landforms are distinct units of the landscape which have characteristic shapes and are produced by natural geologic processes. To evaluate landforms, you need to cast your eyes in every direction around a site to assess the general lay of the land. Slope may be another clue, as is the shape of the slope, i.e., convex, linear, or concave. The parent material may also be a guide, although there is not a perfect correlation between landform and parent material. While there are many specific kinds of landforms, we will confine ourselves to 6 rather general classes of landforms that are commonly found in Oregon.

Upland - Uplands are natural elevations of the land surface. Most uplands have linear or convex sloping surfaces, though some uplands may be nearly level or gently undulating, or even concave. Uplands include moderately sloping foothills and steep mountain slopes. These uplands are likely to have residual or colluvial parent materials. Uplands also include very old, highly dissected stream terraces at valley margins. Because of dissection, the terrain is all sloping, but the parent material is old alluvium. Nearly level ridge crests and hilltops are uplands. So are basalt plateaus in eastern Oregon. Some of these soils have a mantle of old alluvium; others have soils formed in residuum. Sand dunes are uplands, but their parent materials are wind-blown sand. Other situations may be

encountered, but the keys are the general shape of the surface relative to the surrounding landscape, the amount of slope, and the convexity of the slope.

Footslope - Footslopes occur near the base of uplands where the topography is merging from upland to stream terrace or floodplain. Footslopes are usually concave, though linear slopes are permitted. They collect more water than they shed by runoff. Footslopes are not convex, and they are not level. Often the parent materials are colluvial, but depending on the character of adjacent uplands, they may have parent materials that consist of residuum, old alluvium, or wind-blown sands or silts.

Alluvial Fan - Fans also occur at the junction between sloping uplands and nearly level valley floors. Specifically, they form where a rapidly flowing mountain stream emerges from a narrow valley onto a terrace or floodplain. The fan is roughly cone-shaped, with the apex of the cone at the point where upland meets terrace. The cone broadens as the stream spreads sediment onto the valley floor. Sometimes, where several parallel streams emerge from a mountain slope, a whole series of fans will overlap to form a continuous landform of intermediate slope between the upland and the lowland. The gently sloping surface of a fan is linear or very gently convex. The parent material is recent alluvium.

Flood Plain - Floodplains are the nearly level surfaces adjacent to stream channels. Part of the flood plain is inundated every time the stream overtops its banks. Any given flood may not inundate the entire floodplain, but all parts of the floodplain will be covered with water at least once every 100 years. Floodplains are usually nearly level, but some have slopes up to 5 or 6 percent. Undulations caused by scouring of overflow channels may give the floodplain some relief, especially in areas right next to large rivers. The parent material on a flood plain is recent alluvium.

Stream Terrace - Stream terraces are abandoned flood plains. Several times during the geologic history of an area, either changes in sea level or uplift of the land have caused renewed incision of rivers into the landscape. Such a river cuts down through its existing flood plain and establishes a new flood plain at a lower level. The old flood plain is left high and dry as a terrace

that is no longer subject to flooding. Terraces have the same nearly level shape as flood plains, but they are at higher elevations.

At the junction between a terrace and a floodplain is a rise, called an escarpment. Sometimes the escarpment is very obvious; at other times it may be a very subtle rise that requires close observation to detect. Some rivers may have a series of two or three terrace levels, each separated by an escarpment. Such compound landforms resemble a giant set of stairs. In other cases, lateral erosion by a river may remove all of the floodplain on one side, so the river may be flowing at the base of a terrace which it never overtops. In such cases the floodplain on one side of the river will be distinctly lower than the terrace on the other side. Because terraces have been abandoned, their parent materials are old alluvium. Soils on terraces are generally older and more developed than soils on flood plains.

Lake Plain - Lake plains are broad, nearly level surfaces that once were at the bottom of large lakes. They are common in the intermountain basins of Klamath, Harney and Lake counties. The Willamette Valley once held a large lake, too, but the old lake bottom is virtually indistinguishable from a stream terrace. Detailed, regional geologic studies are necessary to tell the difference. Similarly, there are some old lake basins in central Oregon, the Columbia basin, and Baker, Union and Umatilla counties. The parent material of lake basins is old alluvium.

GEOLOGIC ORIGIN OF A, B, C, AND R HORIZONS

This refers to what is commonly called parent material. Strictly speaking, parent material is the original material that has since been developed into A and B horizons. If the original materials were homogeneous, then we can assume that the C horizon is pretty much like the parent material of the A and B horizons. If they were not, then present-day C and R horizons may be quite different from the original parent material of the A and B.

Many Oregon soils have a rather complex history, and simply stating the parent material of the A and B horizons fails to tell the whole story. The record embodied in the whole soil profile, including C and R horizons, can tell us much more about the geologic origin of the site. Since most

Oregon soils are relatively young, the influence of original materials is still noticeable. As soils age, processes of soil development largely override the characteristics inherited from the original materials.

Described below are 7 major classes of geologic materials. Many soil profiles display only a single class, although there may be evidence of several layers within a class, such as alluvium, or volcanic materials. Many other soils, however, contain clear evidence that within the depth of judging there are two or even three different kinds of geologic materials. Examples include wind-blown silts (loess) resting directly on basalt, layers of volcanic ash interstratified with alluvium, and lacustrine material overlying residuum or colluvium. Major clues to the presence of such discontinuities are abrupt textural changes, changes in the amount of coarse fragments, and color changes. As you evaluate the soil, then, if you think the entire profile has a common origin, check the geologic material class that is most appropriate. If it is clear that two or more kinds of materials have influenced the soil we see today, then check the response for two or more on the scorecard.

Residuum - This is unconsolidated weathered or partly weathered mineral material that accumulates by disintegration of bedrock in place. Different kinds of rocks give rise to different kinds of residuum. Basalt, andesite, and volcanic tuff weather to clayey soils. Granite and coarse sandstones weather to loamy and sandy parent materials. Siltstones and fine grained sandstones weather to silt loam and silty clay loam textures.

In the very strictest sense, residual materials have not been moved from the place of weathering. If we applied this concept rigorously, however, we would have virtually no residual soils in Oregon. Small movements due to tree throw, animal mixing, creep, and localized slumps are nearly universal, particularly in the upper foot or so of soil. Such movements should not exclude a material from residuum, as long as we can be reasonably sure that the entire profile formed from material weathered from the rock that underlies the landform.

Generally, as depth increases in a residual material, there is a gradual increase in the amount and size of rock fragments, and they are less and less weathered. Some soils, however, may have relatively unweathered rock fragments throughout, especially in eastern Oregon, where low rainfall precludes rapid chemical weathering.

Residuum is common on uplands and on some footslopes. It does not occur on any other landform.

Colluvium - This is unconsolidated material that is transported locally on steep slopes or is deposited at the base of steep slopes, primarily due to the action of gravity. Water may influence colluvial movement, either by weakening the strength of a soil mass upslope, or by local, unconcentrated runoff. In western Oregon, colluvial deposits may have relatively unweathered rock fragments mixed uniformly throughout. In eastern Oregon this criterion may not serve to distinguish colluvium from residuum. Colluvium is a common material on footslopes and on steep uplands.

Recent Alluvium - Alluvium refers to sediments deposited by running water. All streams and rivers carry a load of suspended sediments, particularly during periods of heavy runoff. When a river floods, the velocity of flow of floodwater is much less than the velocity in the main channel. Suspended sediments settle out on the floodplain, with the coarsest sediments settling out nearest the river, and successively finer sediments being carried further away to settle out in quiet, backwater areas. Repeated episodes of flooding result in gradual accumulation of thick deposits of sediment on the flood plain. These deposits may have fairly uniform textures, or they may be distinctly stratified into layers of widely different textures. Such stratification can give rise to the use of Roman numerals to identify different deposits, although the entire section is all alluvium.

Recent alluvium refers specifically to materials on the flood plains of modern rivers. Fresh sediments may be added yearly or every few years. Soils in recent alluvium are therefore quite young, and may have nothing more than A/C profiles. If the period between deposition of fresh sediments is longer, the soil may have a simple A/B/C profile.

Recent alluvium is also the geologic material of an alluvial fan that is actively growing by deposition of a modern stream emerging from steep terrain. It too is often stratified, and sand and gravel layers are not unusual.

Old Alluvium - This is alluvium associated with a stream terrace or an abandoned alluvial fan. The alluvium was once laid down as recent alluvium on a flood plain, but abandonment of that flood plain means that there are no further deposits of fresh sediments. Soils developed

in old alluvium are older than soils in recent alluvium and usually have distinct horizon development.

Lacustrine Sediments - These are unconsolidated sediments deposited at the bottom of a lake. They are usually finely stratified layers of silts and clays. Some sandier deposits may occur near the shoreline of the old lake. In south-central Oregon, white layers of silty diatomaceous earth may be interstratified with other sediments. Lacustrine deposits often exhibit distinct laminations which are apparent as platy structure. Lacustrine materials occur only on lake plains.

Wind-Blown Sands and Silts - Wind-blown sands take the form of dunes. They occur primarily along the coast, in the Columbia Basin, and in a few other isolated areas throughout Oregon. The sand was derived originally from a beach deposit or from a lacustrine or floodplain deposit. Since it has been reworked by the wind, however, it is customary to refer to the material as wind-blown, or eolian sand.

Wind-blown silt is called loess. Again the silts were originally deposited in a lake basin or on a floodplain, but they have since been picked up and transported by the wind, then redeposited as a blanket of varying thickness over preexisting topography. Loess is a common parent material overlying basalt on the Columbia plateau in north central Oregon. It is thickest near the Columbia River and thins southward. The texture also changes from a sandy loam at the river to silt loams and silty clay loams with increasing distance. Soils developed in loess can be quite productive, but they are particularly susceptible to erosion. Loess occurs mainly on uplands, but also on some footslopes.

Volcanic Ash - Volcanic ash is fine-grained material ejected from a volcano and deposited in varying thicknesses. Strictly speaking, ash particles are less than 2 mm in diameter, the same as fine earth. For our purposes, however, we will include with volcanic ash those larger fragments, commonly referred to as "popcorn pumice," that were deposited close to the source. Some ash deposits are the result of wind-borne transport over several 10's or 100's of miles. In the vicinity of a volcano, however, mixtures of hot gases and ash can literally flow over the surface of the ground without being sorted by wind. Volcanic ash thus includes airborne ash and ash flows.

Volcanic ash consists of a mixture of 3 kinds of particles; glass shards, silt and sand sized pumice fragments, and rock fragments torn off the pre-existing wall of the volcano. Ash commonly has silt loam or sandy loam textures, becoming coarser close to the volcano. Ash typically has a very low bulk density and tends not to compact under applied loads. It is usually found on uplands and footslopes.

STONINESS AND ROCKINESS

Stoniness refers to the amount of individual stones larger than 25 cm in diameter in the soil or exposed at the surface. Rockiness refers to the amount of the landscape surface that consists of bedrock outcrops. Neither stones nor rock outcrops are considered as part of the soil per se because they are so large as to exclude both fine earth and pore space from a large volume of the soil. Both are important characteristics of the site, however, because of their influence on cultivation and other forms of agricultural management.

Stoniness and rockiness are judged according to the percent of the soil surface covered by detached stones or rock outcrops. Four general classes are used here. Each is defined quantitatively, but each is also related to the severity of impact on agricultural management. Because stones tend to be randomly scattered over the soil surface, whereas rock outcrops are concentrated in small areas with larger areas of rock-free soil between, different percentage limits are used to define classes of stoniness than to define classes of rockiness.

Not Stony/Not Rocky - No stones or rocks are present, or there are too few to interfere with tillage.

Stones cover less than .01% of the area.
Rock outcrops cover less than 2% of the area.

Stony/Rocky - There are enough stones or rock outcrops to interfere with tillage but not to make intertilled crops impractical.

Stones cover .01 to .1% of the area--approximately equivalent to stones 1 foot in diameter spaced 30-100 feet apart.

Rock outcrops cover 2-10% of the area--outcrops are approximately 100 to 300 feet apart.

Very Stony/Very Rocky - There are so many stones or rock outcrops that tillage of intertilled crops is impractical. The soil can still be worked for hay crops or improved pasture.

Stones cover .1% to 3% of the area--approximately equivalent to stones 1 foot in diameter spaced 5-30 feet apart.
Rock outcrops cover 10-25% of the area--outcrops are approximately 30 to 100 feet apart.

Extremely Stony/Extremely Rocky - Stones or rock outcrops are so widespread that no agricultural improvements are possible. Some soils still have limited value as native pasture or range.

Stones cover more than 3% of the area.
Rock outcrops cover more than 25% of the area.

SLOPE

Slope refers to the inclination of the surface of the soil area. While we usually think of the slope as the gradient, measured in percent, slope also has characteristics of shape and length. Slope shapes are described as linear, concave, or convex. We used this characteristic to describe some of the landforms. Slope length is important in assessing overall erosion potential, as long slopes permit water flowing over the surface to flow farther and build up speed, thereby increasing erosion. Slope gradient is important because as slope increases, the erosion potential increases, irrigation suitability decreases, operation of farm machinery becomes increasingly difficult, and overall agricultural suitability decreases.

Slope gradients are measured with an Abney level or a clinometer. Consider a representative area surrounding the soil pit, and measure the slope from a point well upslope from the pit to a point about equally far downslope. Always try to measure the slope in the direction that water would run down the hillside. Expressing slope as the % expresses the vertical change in elevation for each 100 feet of horizontal distance. This is commonly called the "rise over the run."

Five classes of slope are commonly used in Oregon. With practice you may be able to estimate slope close enough

to determine the class without using an instrument. The classes we'll use are listed below.

Nearly level	0-3%
Gently sloping	3-7%
Sloping	7-12%
Moderately steep	12-20%
Steep	>20%

ASPECT

One final site characteristic is the aspect of the slope. Aspect is the compass direction that the slope faces. Southerly aspects are exposed to the sun for longer periods of time each day, and are more nearly perpendicular to the sun's rays than northerly aspects. Soils on south aspects tend to be hotter and droughtier than soils on north aspects. This is often reflected in the vegetation, in that northerly aspects will have trees growing on them, while southerly aspects will have only grasses. Because of the vegetation difference, soils on southerly aspects are more susceptible to erosion, and they are often shallower soils than on northerly exposures. For all of these reasons, soils on southerly aspects tend to have considerably lower productivity potentials than similar soils on northerly aspects. The only drawback to northerly aspects is that at a given elevation, the growing season may be quite a lot shorter, and it takes longer for the soil to warm up in the spring.

Easterly and westerly aspects are intermediate in their response to sunlight and moisture supply. In general, an easterly aspect will be more like a northerly aspect, while a westerly aspect will be a little more like a southerly aspect.

CHAPTER 6. MANAGEMENT INTERPRETATIONS

In the beginning we said that soil is like a book of history. Learning how to read the book involves learning how to identify horizons, to describe their characteristics, and to evaluate intrinsic behavior of the whole soil. Now that we have done that, we can focus our attention on predictions of soil behavior under various kinds of management. If the predicted response is not acceptable, e.g., if it were to cause excessive erosion, then we must make a judgment of how managment should be changed to bring expected responses in line with desired goals. Management interpretations are difficult to judge, because 1), they depend on interactions among several soil factors, 2), they are often crop specific, and 3), they are affected by climatic conditions. In order for this manual to have state-wide applicability, it will be necessary to generalize considerably. The guidelines given in the sections that follow should be adequate for soil judging contests, but you should recognize that there may be exceptions to every one of them in specific cases. Oregon has such a diversity of soils, climate, types of agriculture, and management practices that a general manual like this simply cannot account for every possibility.

FEASIBILITY OF ARTIFICIAL DRAINAGE

Soils that are less than well drained can often be improved by artificial drainage. Ditches, subsurface drains, or combinations of the two may be required. The effectiveness of such measures, however, as well as their design, installation, and cost, depend on the properties of the soil being drained. Moderately well drained soils with good permeability are easy to drain. Clayey soils, soils with shallow restrictive layers, and soils that are saturated for very long periods of time are difficult to drain.

Another factor that affects drainage feasibility is the availability of outlets, i.e., having someplace to discharge water removed from the soil. Outlets may not be available in low-lying, depressional areas or on very broad, level surfaces where the water table is at or near the surface much of the time. These situations, however, cannot always be evaluated from the characteristics of the soil profile or of the immediate site. Regional studies and seasonal observations may be required. For that reason, information on

the availability of outlets will be provided at each pit. Use that information in conjunction with the soil characteristics listed in the following Guide to evaluate drainage feasibility. Remember, too, that drainage feasibility is not the same as drainage effectiveness. Feasibility refers to the relative ease or difficulty of designing, installing, maintaining, and paying for an adequate drainage system. Soils with good feasibility may require nothing more than tile lines placed at 60 or 30 foot spacings. Soils with poor feasibility may require tile at 10 or 20 foot spacings, sumps, pumps, valves, etc., and the cost may well be prohibitive. Nevertheless, such measures might be quite effective, and with some kinds of high-value crops they might pay for themselves.

Guide for Determining Drainage Feasibility

	Good	Fair	Poor
Depth to Restrictive Layer	≥120 cm	≥60 cm	<60 cm
Drainage Class/ Permeability above restrictive layer	MW/slow	MW/slow	MW/slow
	SWP/mod	SWP/slow PD/mod	SWP/slow PD/slow
Outlets	Avail.	Avail.	Not avail.

SUITABILITY FOR IRRIGATION

The best soils for irrigation are deep, nearly level, well drained soils with good permeability and moderate to high infiltration rates. Departures from these conditions may lower the irrigation suitability. In judging irrigation suitability, we are judging only the soils ability to be irrigated. Availability of water for irrigation is not a factor to be considered. Neither is the specific crop to be irrigated.

Several factors must be considered before an overall decision on irrigation suitability can be made. These are listed on the left hand side of the Guide for Determiing Irrigation Suitability. The first factor, slope, affects the choice of an irrigation system. Flood or furrow irrigation works well only on soils with slopes less than 3%. Wheel lines and center pivots will work on slopes up to 7%, but with increasing difficulty. Above 7%, solid sets or hand-move systems are about all that can be used. Irrigation is generally not feasible on slopes greater than 20%. Infiltration interacts with slope. Moderate or rapid rates are preferred,

Guide for Determining Irrigation Suitability

	Excellent	Good	Fair	Poor	Non-irrigable
Slope/Infiltration	0-3%/slow 3-7%/mod.	3-7%/slow 7-12%/mod	7-12%/slow	12-20%/slow	>20%
Effective Depth	Unrestricted	≥100 cm	≥50 cm	≥25 cm	<25 cm
AWHC	High	Medium	Low	Very low	Very low
Internal Drainage/ Drainage Feasibility	WD MWD/Good SWP/Good	WD MWD/Fair SWP/Fair	WD MWD SWP PD/Fair	Any	Any
Stoniness/Rockiness	None	None	Stony/Rocky	V. Stony V. Rocky	Ext. Stony Ext. Rocky

but slow infiltration can be tolerated on level slopes. As the slope increases, however, restricted infiltration reduces the rate at which water can be applied. Consequently, the choice of irrigation system, the amount of equipment required, and the choice of crop may be more limited. Also, the efficiency of irrigation may be reduced, and the potential for runoff of excess water is increased. Silt loam soils under center pivots illustrate this problem. At the outer end of the circle, water must be applied at rates in excess of the soil's infiltration rate. The excess water runs off, which not only wastes water and energy, but also can cause erosion.

Effective depth affects the total water holding capacity. At shallower depths, irrigation must be done more frequently with less water applied each time. This requires more labor and equipment, and the costs increase accordingly. Available water holding capacity (AWHC) is listed because some soils with unrestricted depth nevertheless have low AWHC. Sands and loamy sands are the major problems. Center pivots work very well on these soils, but they are expensive, and crop production on sandy soils is totally dependent on the reliability of uninterrupted electricity and water supplies.

Drainage class per se is not a serious limitation as long as the soil can be easily drained. Thus a somewhat poorly drained soil may have excellent irrigation suitability if it is adequately drained. High water tables restrict root growth, however, so irrigation will be less efficient if water tables persist. Good permeability is necessary to move water down through the soil to make room for continued applications. Rapid permeability, however, is not the best, because it enhances leaching and again requires less water at more frequent intervals. Stones or rock outcrops seriously limit the kind of irrigation equipment that can be used.

To use the Guide for Determining Irrigation Suitability, start with the first characteristic and go across the row until you find the first criterion that fits your soil. Then move down that column, checking each additional characteristic. If the criterion fits, go down to the next characteristic. If it doesn't fit, move across the row until you find one that does. From that point on, keep moving down the new column. You never move back to the left.

MOST INTENSIVE CROP

Soil characteristics, in conjunction with the climate of an area, pretty much dictate the most intensive kind of

cropping system that is feasible. Deep, well drained, fertile soils that have an adequate water supply and a long growing season can be used for a wide variety of crops. Restrictions imposed by texture, depth, permeability, drainage, rainfall, or temperature reduce the choice of crops accordingly. For example, shallow stony clay loam soils under 10 inches of rain in eastern Oregon are suited only for range management. Thus, evaluation of most intensive crop is really a measure of the potential productivity of a soil.

There are approximately 150 different kinds of agricultural crops grown in Oregon. We are going to group those into one of 6 very general categories. Obviously, then, there will be some local exceptions to the kinds of guidelines specified here. Very good soil managers, in particular, may be able to use their soils more intensively than these guidelines may suggest. Conversely, a poor manager may not be able to manage his soil up to the potential that really exists.

Most farmers manage their fields in a crop rotation. As a result, a soil well suited for potatoes (a row crop) may periodically be used for wheat so as to control soil-borne potato diseases. Or a soil suitable for wheat may be rotated with alfalfa to build up nitrogen and organic matter, or with grass seed to control disease and erosion. The most intensive crop, then, may not be the crop currently grown on the soil. Similarly, a farmer may intentionally decide to use a highly productive soil for a less intensive crop, e.g., irrigated pasture and hay in an intensely managed cattle operation. This does not necessarily represent underutilization of soil potential, but instead a decision to take advantage of the quality of soil resources in a different way. On the other hand, we can find plenty of examples where good soils are not being fully utilized. We can also find examples where a soil is being used at an intensity beyond its potential. Row cropping land with a high erosion hazard involves substantial risk-taking. A farmer may be able to get away with it for a while, but severe erosion over several years may ultimately ruin the soil resource.

Because most of the soil properties that affect choice of crop also affect irrigation suitability, we will use that interpretation as the starting point for selection of the most intensive crop in a rotation. Adjustment for specific slope and climatic conditions will be made as necessary. The 6 crop categories are discussed briefly below, followed by a guide for selecting the most intensive crop.

Row Crop/Specialty Crop - This category includes all the vegetable crops grown in Oregon--corn, beans, onions, carrots, garlic and many others. All these crops require irrigation; irrigation water, therefore, must be available. Soils with excellent or good irrigation suitability are preferred, although a few soils with only fair irrigation suitability are acceptable. Even if the soil is right, however, climatic restrictions on total heat units or length of growing season prevent growing row crops in some parts of Oregon. The row crop category will also be used for soils that are currently in orchards, grapes, or other specialty crops like cranberries or lily bulbs, regardless of the irrigation suitability.

Legume/Hay - If irrigation water is available, but the soil is not suited for row crops, then alfalfa, clover, or grass hay is the next most intensive crop. Generally, the irrigation suitability should be at least fair, but some soils with poor irrigation suitability are acceptable. Legume/hay is also adapted to cool temperatures on the coast and short growing seasons at high elevations. Keep in mind that there's a lot of alfalfa grown in Oregon on soils that could support row crops. Again, that's not so much underutilization of the soil resource as it is intentional management for specific objectives.

Dryland Wheat - If irrigation water is not available, then dryland wheat is the most intense crop possible. Suitable soils should have the qualities of a soil with at least fair irrigation suitability. Slopes, however, may range up to 35% as long as all other criteria are fair or better. The critical factor for dryland wheat is moisture. Western Oregon has plenty of rainfall. Those areas in eastern Oregon that receive more than 18" of rain also have adequate moisture. Below that amount, successful wheat production, even in a fallow system, depends on the amount of water that can be stored in the soil. As rainfall decreases, the minimum available water holding capacity must increase to compensate for lower rainfall. Occasionally you'll see a field of irrigated wheat. That's not the most intensive use of the soil, however, and it's probably being grown as part of a rotation with alfalfa or a row crop.

Permanent Pasture - Some soils are so limited by texture, depth, drainage, slope, or other conditions that it is not feasible to use them for cultivated crops. If the irrigation suitability is at least poor, however, they can be managed for permanent pasture. In addition,

some soils that are non-irrigable because of steep slopes can also be managed for permanent pasture. Water is also a key factor. In western Oregon, rainfall is sufficient for permanent pastures without irrigation. If irrigation water is available, supplemental irrigation may be profitable. In eastern Oregon, pastures must be irrigated, so irrigation water must be available.

Some poorly drained, nearly level soils on broad terraces can be used for grass seed production. While this is a little more intensive than permanent pasture, for purposes of generalization, grass seed and permanent pasture are grouped together.

Forest - Where rainfall is plentiful, soils on steep slopes cannot be managed for agricultural crops. Managed tree production, however, can be profitable, and it is a wise use of the soil resource. Forestry is also the most appropriate use for soils that are non-irrigable for reasons other than slope, as long as there is enough rainfall.

Range - In eastern Oregon, where rainfall is limited, non-irrigable soils are limited to utilization for range. Most can be managed for improved range production with such practices as sagebrush and juniper removal, seeding of adapted grasses, fencing to allow rotational grazing, and development of stock ponds. Rangeland use is also the most intensive use for soils in low rainfall areas that have no source of irrigation water.

Guide for Selecting Most Intensive Crop

A. Irrigation Water is Available

1. Row Crop/Specialty Crop
   a. All soils with excellent or good irrigation suitability.
   b. Sandy soils with fair irrigation suitability.
   c. Other soils with fair irrigation suitability on 0-3% slopes.
   d. Soils currently used for orchards, grapes, or other specialty crops, regardless of slope or irrigation suitability.

2. Do not check row crop under the following situations:

   a. Coastal valleys and terraces.
   b. High elevation basins in Lake, Harney, and Baker counties.

c. Soils that have a pH >8.4.
d. Soils currently used for row crops, even though wise use and management dictates that they shouldn't be.

3. Legume/Hay
   a. Non-row crop soils with at least fair irrigation suitability, including
      1) coastal valleys and terraces
      2) Lake, Harney, and Baker counties
   b. Soils on 12-20% slopes for which slope is the only reason for poor irrigation suitability.
   c. Do not check legume/hay for soils with pH >8.4.

4. Permanent Pasture/Grass Seed
   a. Soils with poor irrigation suitability for one or more reasons other than slope.
   b. Sodic soils with pH >8.4.

B. Irrigation Water is Not Available/Non-Irrigable Soils

1. Dryland Wheat
   a. Slopes up to 35% are permitted as long as all other irrigation criteria qualify for at least fair.
   b. soil pH must be ≤8.4.
   c. The following rainfall/AWHC conditions must be satisfied:

Rainfall (in.)	AWHC (cm)
>18	≥7
12-18	≥12.5
11	≥15
10	≥17.5
9	≥20
8	≥22.5
7	≥25

2. Permanent Pasture--Rainfall must be >18"
   a. Soils with poor irrigation suitability for which factors other than slope control irrigation suitability.
   b. Non-irrigable soils, up to 35% slope, for which slope is the only reason for non-irrigability.

3. Forest--Rainfall must be ≥18"
   a. All soils on slopes >35%.
   b. Non-irrigable soils for which factors other than slope contribute to the non-irrigable rating.

4. Range--Rainfall must be <18"
Any soil that doesn't qualify for wheat.

EROSION CONTROL PRACTICE

The need for erosion control practices depends on a soil's erosion hazard and the most intensive crop that can be grown. For some crops, like hay and pasture, the crop itself provides much of the protection needed. For others, like row crops and wheat, specific management practices are needed to prevent soil erosion. Regardless of the size of the erosion problem, conservation is something that farmers must be aware of, for any soil, if managed improperly, is subject to erosion that reduces the quality of the soil resource for future generations.

The right kind of erosion control system for any particular field, farm or forest can only be determined by an on-site inspection. There are no magic formulas or prescriptions that fit every situation. Sometimes adequate erosion control can be achieved by simple application of one of the general practices described below. In other cases, two or three different kinds of practices may be needed. In still others, there may be measures not included in this list that are appropriate. The important thing is to recognize the problem, know the various kinds of erosion control practices available, and use a good healthy dose of common sense in managing soils so as to minimize erosion. For the contest, select from the practices below the one that is the most important, even though additional practices would provide the best protection.

Intermittent Channel Control - Any time water concentrates in a channel, its erosive potential is greatly increased. Even on level, but slowly permeable soils, excess rainfall may collect and run off in surface channels. There are several ways to minimize this problem. One is to maintain permanent sodded waterways, even through row crop or wheat fields. Sometimes natural channels can be diverted around a field. Occasionally more sophisticated techniques using drop structures and underground transport through pipes will do the job. Channel control is appropriate on some row-cropped soils, for wheat in western Oregon, for soils growing legumes or hay, and for poorly drained, level soils in grass seed production.

Cover Crop - Many soils used for row crops are left bare during the winter growing season. Planting a quick-growing crop like cereal rye immediately after harvest can help hold the soil in place. In the spring, the crop can easily be plowed or disked into the soil. Thus the cover crop helps to maintain soil organic matter as well as provide erosion protection. Cover crops are appropriate for water erosion control on sloping soils used for row crop protection, and for wind erosion control on all soils used for row crops.

Stubble Mulch - This is a method of residue management that involves partial incorporation of wheat straw into the surface soil. Trashy fallow and minimum tillage refer to this same practice. The idea is to create a rough surface that slows down water runoff or wind speed, and improves infiltration. Stubble mulch is a good practice for erosion control in most wheat fields throughout the state.

Diversion Terraces - These are deep ditches built on the contour to catch water coming down the slope and divert it laterally to a waterway where it can run on down the slope without causing further damage. Intermittent channel control is therefore required along with diversions. So is stubble mulch. On long slopes, 2, 3, or even 4 diversions may be necessary so that water never has the opportunity to flow overland very far. Diversion terraces are most common on steep slopes used for wheat production in eastern Oregon.

Strip Crop - With limited rainfall, dryland wheat can be grown in a given field only every other year. During the intervening, or fallow year, the soil is left bare--or stubble mulched--so that the soil's water holding capacity can be restored to its maximum. Where wind erosion is a problem, fields can be managed in alternating strips of wheat and fallow. The strips are perpendicular to the dominant wind direction. Standing wheat slows down the wind and partly shelters the adjacent strip downwind. By keeping the strips narrow, there is much less opportunity for sustained winds to travel far enough over bare ground to pick up much soil. And if soil does blow, the next wheat strip will trap some of it.

Controlled Grazing - This is the proper practice for permanent pastures and for rangeland. In most situations the purpose is to prevent overgrazing, which reduces the natural vegetative protection and increases soil erosion.

This can be done by using proper stocking rates and by the use of fences and stock ponds to allow rotational grazing. On subclover pastures in western Oregon, controlled grazing means intentional heavy stocking rates, for subclover does best when it is very closely grazed. Some permanent pastures on sloping soils may need some channel control as well.

Watershed Management - Erosion control is just as important in forestry as it is in agriculture. Unfortunately, there are no categories of erosion control practices that apply generally to specific situations. Each timber site must be assessed individually. The key ingredient is to maintain maximum infiltration. Avoiding compaction is important, as is the proper location and design of logging roads. Choosing a suitable harvest method can accomplish much of the needed protection. Clear cutting is quite acceptable for many soil/slope combinations, but it can be quite damaging in others. Watershed management means a system approach, in which the soil, landscape, and vegetation are all considered in developing a suitable forest management scheme.

Since the proper choice of erosion control practice depends on the most intensive crop, each crop category is listed below, and the most appropriate practices are given for the conditions that may be encountered. Remember that in reality combinations of two or more practices may provide the best control, but for the contest only one will be selected.

Row Crop/Specialty Crop

1. All soils on floodplains -- COVER CROP
2. Western Oregon soils, 0-3% slopes -- CHANNEL CONTROL
3. Western Oregon soils, >3% slopes -- COVER CROP
4. Eastern Oregon soils with wind erosion -- COVER CROP

Legume/Hay -- CHANNEL CONTROL

Dryland Wheat

1. Western Oregon
   a. Low erosion hazard -- CHANNEL CONTROL
   b. Moderate or high erosion hazard -- STUBBLE MULCH

2. Eastern Oregon
   a. Wind erosion, ≤10" rain -- STRIP CROP
   b. Wind erosion, >10" rain -- STUBBLE MULCH
   c. Low or moderate water erosion -- STUBBLE MULCH
   d. High or very high water erosion -- DIVERSION TERRACES

Permanent Pasture -- CONTROLLED GRAZING

Forest -- WATERSHED MANAGEMENT

Range -- CONTROLLED GRAZING

REACTION CORRECTION

For most crops the optimum pH is in the neutral range, pH 6.6 - 7.3. Modest departures from this range are not serious, however, so we will broaden the range a little before soil pH calls for a management correction.

Excess acidity in soils causes reduced availability of several plant nutrients. It may even cause some elements to be toxic to plant growth. Soil acidity is corrected by adding lime in amounts ranging up to 4 or 5 tons per acre. The actual amount applied depends on factors such as the amount of acidity to be neutralized, the crop to be grown, the purity and fineness of the liming material, and the extent of mixing into the soil. For our purposes we will regard the soil as needing a correction for acidity if the pH is less than 6.2.

Excess alkalinity is caused by excess sodium in the soil. Such soils have very poor structure, so that permeability is low and the soil has a very poor physical condition for plant growth. Several practices may be necessary to correct alkalinity. Gypsum or sulfur should be applied to replace the excess sodium. Irrigation is necessary to leach out the sodium, and drainage is needed to carry the sodium-laden leaching water completely out of the soil system. Correction of alkalinity is an appropriate measure if the pH exceeds 8.4 and irrigation water is available. If irrigation water is not available, reclamation is not possible, and the soil will have to be used for rangeland. In this case, check none, even if the pH is greater than 8.4.

LIMITATION FOR SEPTIC TANK DRAINFIELDS

Any home built in an area not served by public sewers must have some kind of on-site waste disposal system. By

far the most common procedure is to discharge all wastes into a septic tank, from which effluent then passes through a series of perforated tile lines for treatment and disposal in the soil. The adequacy of these systems depends more than anything else on the properties of the soil. Most drainfields work quite well in deep, well drained, permeable soils. But if the soil has a slowly permeable layer, or a periodically high water table, septic tank effluent may not receive adequate treatment, and it may be the source of a health hazard.

Soil must do three things for us if a drainfield is to function properly: accept the effluent, treat the waste, and dispose of the wastewater. All three depend heavily on soil permeability. Since treatment is a biological process which requires aerobic conditions, wastewater must move through the soil fast enough to prevent a build-up of saturated conditions, but slowly enough for microorganisms to remove hazardous constituents. Soils that are less than well drained have periodic water tables that interfere with proper drainfield operation. Shallow soils don't have enough volume of soil available for treatment, and the hazard of effluent breaking out at the surface is increased. Sloping soils are poorly suited for drainfields because of the likelihood that effluent will concentrate at the ends of tile lines and either break out at the surface or flow too rapidly downslope in the soil. Floodplains are not suitable places for drainfields because floodwaters can become contaminated with untreated effluent.

Soil scientists have for years tried to provide assistance to land use planners and prospective homebuilders by rating soils in terms of their limitations for septic tank drainfield performance. General categories of slight, moderate, and severe indicate the relative suitability of a soil for drainfield installation. Soils with a slight limitation generally can be used for drainfields without modifications. Soils with moderate limitations generally can be used for drainfields, but some special practices may be needed. Increasing drainfield size, installing drainage to remove seepage water, or adding a little extra soil to the surface are examples of the kinds of things that may be needed. Soils with severe limitations cannot be used for drainfields without extensive--and expensive--modifications. Complete removal of the natural soil and replacement with more permeable soil may be necessary. Or extensive drainage to remove excess water may be required. Sometimes pumps and valves can be used to better distribute wastewater, or to take it further away to a site with more suitable soils.

In any case, the rating is an interpretation based on those soil properties that are most closely related to drainfield performance. The interpretation is made very much as for irrigation suitability, i.e., we evaluate one property at a time, and use the rating determined by the most limited property.

Key for Determining Limitation for Septic Tank Drainfields

	Slight	Moderate	Severe
Effective Depth of Rooting	>120 cm	>90 cm	<90 cm
Permeability	Moderate	Rapid or Moderate	Rapid to Slow
Drainage Class	WD	WD, MWD	Excessive to Poor
Slope	0-7	0-12	>12
Site Position	All except Floodplains	All except Floodplains	All

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RULES FOR CONDUCTING SOIL JUDGING CONTESTS IN OREGON

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RULES FOR CONDUCTING SOIL JUDGING CONTESTS IN OREGON

The Manual for Judging Soils in Oregon describes in some detail the processes of identifying soil horizons, describing their properties, and making selected interpretations of soil behavior. Many of the principles discussed are widely applicable outside of Oregon. The conduct of a soil judging contest, however, requires some rather specific guidelines so that every contestant can be treated equally and fairly. Rules are necessary to eliminate ambiguities and to spell out the criteria that will be used by official judges in filling out and grading score cards. The purpose of this manual is to document the procedures that will be used in Oregon for organizing and operating such contests. Some of the procedures are general, and apply to the contest as a whole. Others are specific to individual entries on the scorecard.

CHAPTER I. GENERAL PROCEDURES

The two areas of general concern involve the structure of the contest and the format and grading of the scorecard. Rules for each one are discussed in the following sections

CONTEST STRUCTURE

An official contest has 3 soil pits. Each contestant is given 30 minutes for judging each pit. In addition, one extra pit should be available for practice. The following information will be made available at each pit:

1. The total depth of soil to be judged.

2. The number of horizons recognized by the official judges within the total depth to be judged.

3. Depth from the surface to each horizon boundary. This means that students will not be asked to locate horizon boundaries. They will simply be asked to properly name and describe the properties of horizons that are preselected by the official judges.

4. Which horizons are to be judged, up to a maximum of four. In some soils, that may mean the first four in sequence. Other soils may have only two or three horizons. In still others, students may be asked to judge only the first three, or the first, second, and fourth, or horizons 1, 2, 3, and 5, or some other combination. In any case, the official judges will determine which horizons are to be judged at each pit, and that information will be made available.

5. The pH of each horizon.

6. The amount of rainfall at the site.

7. Whether or not irrigation water is available.

A small area will be clearly marked on one face of the pit as a reference area. This represents the area used by the official judges for determination of depths to each horizon boundary. It is a hands-off area. Students should recognize that natural soil variation may very well cause the depths to differ along the entire face of the pit. That's why depths are given rather than being left to judge. But as you describe the properties of each horizon, you may want to adjust the boundaries at the point you're working up or down a little bit to be sure you're always judging the same horizon the official judges did.

Evaluation of landform and parent material can be made without restricting the boundaries of the site. However, stakes will be placed to demarcate an area within which stoniness/rockiness and slope are to be evaluated.

SCORECARD FORMAT AND GRADING

The front side of the scorecard is devoted entirely to the naming and description of soil horizons. Space is available to describe 4 horizons, although the judges may decide that for a given soil only two or three horizons need to be judged. The back side of the scorecard is used to record properties of the whole soil, site characteristics, and management interpretations.

The entire format of the scorecard is like a multiple choice exam. For each response category, the possible choices are numbered consecutively. After selecting the proper answer, write the number of that answer in the blank beside the characteristic being evaluated. Scorecards will be graded by placing a key sheet beside each column of contestant responses and comparing the numerical answers. If a student writes in the name of the horizon, or the name of the textural class, or any other name, it will be marked wrong.

Two other rules pertain to the filling out and grading of scorecards:

1. There will be one and only one correct answer for each characteristic, front and back.

2. Every question will be graded on its own merit. There will be no conditional grading, i.e. students must give the correct response for drainage, or irrigation, regardless of what they may have checked previously for color, texture, available water holding capacity, or any other property.

CHAPTER II. SPECIFIC INSTRUCTIONS

For many of the items to be judged, the guidelines and criteria given in the Manual for Judging Soils in Oregon are adequate. In some cases, however, additional clarification of ground rules may be necessary to avoid confusion and doubt. In this chapter, each entry on the scorecard will be discussed in the order that it appears.

HORIZON DESCRIPTIONS

Eight characteristics are used to describe each horizon. The eight characteristics, and the possible choices for each one, are listed in the middle section of the front side of the scorecard. Use the same set of choices to record properties for all of the horizons to be judges in a given soil.

Horizon Name - Note that the seven possible responses include several groups of similar horizons. This permits differentiation between major horizons without asking students to be as precise as a professional soil scientist. Similarly, students are not being asked to name many of the special kinds of A, B, or C horizons, to name subdivisions of master horizons, or to name lithologic discontinuities. They should still learn to recognize these features, however. For example, a soil with a thick A horizon might have both an Ap and A12 horizon. The correct response on the scorecard would be number 2 in both cases. Or a soil with a thick B2 might have its 3rd horizon properly named as B21t and the 4th horizon named as B22t. Again, the correct response for both horizons is number 5. Some soils have several C horizons in sequence, all of which would be marked number 6. Lithologic discontinuities should be recognized, for they may affect the decisions on available water holding capacity and parent material. Claypans, fragipans and duripans also should be recognized, even if the judges don't ask you to describe them, because of their potential influence on things like depth, drainage, and permeability.

Horizon Boundary - Judge only the attribute known as horizon distinctness. Use the criteria listed in the Manual. Judge anywhere on the pit wall, but feel free to make visual reference to the area marked off by the official judges.

Texture of the Fine Earth - Twelve classes of soil texture are shown on the textural triangle (Figure 2 in the Manual). Some of these, particularly at the extremes of sand and clay, are combined to form 8 choices on the scorecard. The judges will make their decision on the basis of the "feel" of the soil in the field. While there is no substitute for experience, the guides in the Manual should help you arrive at the correct answer. Mark the number of the correct textural class of the fine earth in the the blank for texture on the scorecard.

Coarse Fragments - Quantitative criteria for classifying the amount of coarse fragments are given in the Manual. If the soil contains stones larger than 10 inches within a horizon, add their volume to the volume of cobbles. Stones lying on the soil surface will be evaluated later as a site characteristic.

Color of the Matrix - Determine the dominant color of ped interiors. This may be done by breaking open a ped to expose a fresh interior surface, or by gently crushing a ped between thumb and fingers. Do not rub the soil to mix colors. Do not be misled by the color of ped coatings. In mottled soils, the matrix color is the one that occupies 50% or more of the interior surface. Matrix color should be determined as the moist color. If the soil is dry, add a drop or two of water to the broken surface and let it soak in before judging the color.

Mottling - The Manual describes four attributes of mottling. You are asked only to determine if mottles are present or absent, and if they are present, the extent of their contrast with the matrix. Terms for describing mottle contrast are defined in the manual. If the soil has a variegated color pattern, and you think those colors are due to parent material weathering rather than soil wetness, mark 1 for no mottling on your scorecard.

Structure Type - The shape of structural peds should be described for each horizon. Possible shapes are defined in the Manual. For judging purposes, both kinds of blocky structure are grouped together, as are massive and single grain types.

Structure Grade - Soils that are aggregated into peds have weak, moderate, or strong structural grade. Make your determination according to the criteria in the manual. If you marked the type as massive/single grain, then you should mark the grade as structureless.

PROPERTIES OF THE WHOLE SOIL

Synthesis of the kind and sequence of horizons and the properties each has enables us to make some inferences about the behavior of the soil as a whole. There are 6 major categories of soil behavior to be judged. They are discussed in Chapter 4 of the Manual and are listed on the upper part of the back side of the scorecard. Each category is followed by the list of choices from which you must select the correct response. As before, write the number that corresponds to your choice in the blank immediately adjacent to the soil characteristic being evaluated.

Effective Depth of Rooting - You can't judge soil that you can't see. So if the soil pit is less than 150 cm deep, and there are no restrictions within the soil, do not assume that rooting is >150 cm. Instead, select the response that expresses the effective depth of rooting within the depth of soil to be judged. That depth will be specified for you at each pit. Remember, too, that the effective depth might be limited by a horizon you were not asked to describe in detail on the front side of your scorecard.

Available Water Holding Capacity - The calculation of AWHC, which is described in the manual, needs to be done very carefully. You will need to refer back to the texture and structure of each horizon, the thickness of each horizon, and the depth of rooting. Once again, every horizon from the surface to the limit of rooting must be considered, even if you did not judge it in detail earlier.

Infiltration - Judge infiltration according to the criteria in the Manual. Remember that infiltration is controlled by the characteristics of the surface horizon only. Coarse fragments do not affect the infiltration rate significantly, as water that enters the soil must move into the pores in the fine earth fraction anyway.

Permeability - The same criteria are used to judge permeability as infiltration, even though the concept is different and the rapid, moderate, and slow classes have different numerical limits. Since permeability of the whole soil is controlled by the least permeable horizon, select your response to fit the permeability class of the horizon that has the slowest permeability. Confine your interpretation to the specified depth of soil to be judged.

Erosion Hazard - Judge the erosion hazard only for water erosion, and disregarding the existing vegetation. Assume that the soil is in its most susceptible state, i.e. a bare surface with no vegetative cover. Because slope is an important criterion, you'll need to measure that before you can continue with the interpretation. You also need to know the texture of the surface horizon and the depth to a restrictive layer. Details are spelled out in the manual.

Internal Soil Drainage - The five classes of soil drainage we'll use are defined in the Manual. Criteria are based on depth to mottles and mottle contrast. Helpful hints may be obtained by assessing landscape position, however.

SITE CHARACTERISTICS

Four characteristics of the landscape that a soil is part of provide useful information about the soil itself and its suitability for various management options. They are discussed in Chapter 5 of the Manual and are listed in the middle section of the back side of the scorecard. Numbered response classes follow each characteristic. Select the appropriate response and write the corresponding number in the blank beside each characteristic.

Site Position - Six general classes of landforms are described in the manual. Since it may be very difficult to distinguish between some of them without regional geologic studies, students will not be asked to differentiate between a footslope and an alluvial fan, or between a stream terrace and a lake plain. There is no limit on the size of area surrounding a soil pit used to judge the landform. Sometimes hills in the distance or a stream half a mile away can provide useful clues.

Parent Material - The seven classes of parent material described in the Manual are condensed into five on the scorecard. Again the reason is that it may be virtually impossible to distinguish between residuum and colluvium or between old alluvium and lacustrine deposits without detailed soil and geologic studies. The most important clues to parent material come from the soil itself and from the landform. The sixth response, two or more classes, is to be used only when there are lithologic discontinuities between different kinds of parent materials, e.g. wind-blown silts over residuum. It is not to be used for colluvium over residuum, or for different strata in an alluvial deposit, since both involve only a single class of parent material. If you mark number 6 on your scorecard, do not write in the numbers of the individual classes that make up the discontinuity, as one and only one answer will be accepted.

Stoniness/Rockiness - These properties are grouped together since soils rarely exhibit both characteristics at the same time. Classes of stoniness and rockiness, and the criteria for evaluating them, are described in the manual. Unlike landforms, stoniness or rockiness should be judged within the area marked off with stakes.

Slope - Slope gradient is also to be determined within the area marked off with stakes. The measurement should be made, however, in the direction that water flows. This may or may not correspond with the direction between two stakes. The use of Abney levels or clinometers will be permitted, but is not required. Five classes of slope, measured in %, are used in the contest as shown on the scorecard. If a slope is determined to be exactly on the boundary between two classes, place it in the higher class.

MANAGEMENT INTERPRETATIONS

The soil judging process is not complete without evaluating the utility of the soil for practical purposes. Five of the interpretations are related to agricultural management. The sixth is for a non-agricultural use. We do not provide more non-agricultural interpretations because most of them require the same or very similar properties and are evaluated in the same way. The one interpretation for septic tank drainfields would seem sufficient to illustrate the process and test your skills without becoming repetitive. All six interpretations are discussed in Chapter 6 of the Manual and are listed in the lower segment of the back of the scorecard. Mark the number that corresponds to the correct response in the blanks beside each interpretation.

Drainage Feasibility - Soils that are excessively drained or well drained do not need drainage. Mark number one on your scorecard. Moderately well drained, somewhat poorly drained, and poorly drained soils all need artificial drainage. Determine the feasibility of drainage according to the criteria given in the manual. Always assume that drainage outlets are available, even though in some situations it might be apparent that they are not.

Irrigation Suitability - This is probably the most complex interpretation to make because of the many factors that must be considered to make a decision. A good healthy dose of common sense will go a long way toward helping you make the proper determination. The official judges, however, will adhere strictly to the criteria specified in the Guide for Determining Irrigation Suitability. This may lead occasionally to a faulty or unrealistic answer, but we'll have to accept that as the price for having a single set of criteria that can be applied consistently to all 800 soils in Oregon. In any case, irrigation suitability is a property of the soil only, and should be judged irrespective of the availability of irrigation water.

Most Intensive Crop - The most intensive crop that is feasible in any part of a crop rotation depends primarily on the irrigation suitability, the availability of water, and the slope. Specific criteria are spelled out in the Manual. If irrigation water is available to irrigable soils, choose from row crop, legumes/hay, or permanent pasture. If irrigation water is not available, consider wheat first. If wheat is not feasible, then consider legume/hay, permanent pasture, or forest/range in that order.

Conservation Practice - The Manual makes it quite clear that a lot of conservation can be accomplished through the proper choice of a crop and the proper use of crop rotations. The conservation practices interpretation refers only to those practices needed in addition to the conservation effected by crop management. If the most intensive crop provides adequate conservation for the soil in question, then no additional conservation is needed. Check the number for none on your scorecard. Some crops, however, do require additional conservation practices, and the practice may change with soil conditions. Specific criteria for making these choices are spelled out in the Manual.

Reaction Correction - Acidity should be corrected if the pH of the surface horizon is below 6.2. Alkalinity should be corrected if the pH of any horizon within the effective depth of rooting exceeds 8.4. At intermediate pH values, check none.

Limitation For Septic Tank Drainfields - Interactions between permeability, drainage, depth, and slope must be considered to make this interpretation. As with irrigation suitability, good common sense is of immense value in making a decision. The judges, however, will abide by the criteria given in the Manual.

Contestant _____ Site _____

School _____ Ag II - IV - 183

SCORE CARD

OREGON STATE SOIL JUDGING

COLOR

Matrix	Mottling
1=Very Dark Brown or Black	1=none
2=Light Brown, Brown, Yellowish Brown	2=few
3=Red, Reddish Brown	3=common
4=Gray, White	4=many

TEXTURE

Fine Earth	Coarse Fragments
1=sand; loamy sand	1=none
2=sandy loam	2=gravelly or cobbly
3=loam	3=very gravelly or very cobbly
4=silt loam, silt	4=extremely gravelly or extremely cobbly
5=sandy clay loam	
6=clay loam	
7=silty clay loam	
8=clay, silty clay, sandy clay	

STRUCTURE

Type	Grade
1=granular	1=structureless
2=platy	2=weak
3=blocky	3=moderate
4=prismatic	4=strong
5=massive, single grain	

HORIZON

Lower Boundary	Name
1=abrupt	1=O1, O2
2=clear	2=A1, Ap
3=gradual	3=A2
4=diffuse	4=A3, B1, B3
5=not present	5=B2, Bx
	6=C
	7=Ccasim, Cr, R

FIRST HORIZON	SECOND HORIZON	THIRD HORIZON	FOURTH HORIZON
___color (matrix)	___color (matrix)	color (matrix)___	color (matrix)___
___mottling	___mottling	mottling___	mottling___
___texture (fine earth)	___texture (fine earth)	texture (fine earth)___	texture (fine earth)___
___coarse fragments	___coarse fragments	coarse fragments___	coarse fragments___
___structure (type)	___structure (type)	structure (type)___	structure (type)___
___structure (grade)	___structure (grade)	structure (grade)___	structure (grade)___
___boundary	___boundary	boundary___	boundary___
___name	___name	name___	name___

Total Front ☐ Total Back ☐ GRAND TOTAL ☐

Ag II - IV - 184 **Properties of the Whole Soil**

____ Effective Depth
- 1 = 0-25 cm (0-10 in.)
- 2 = 25-50 cm (10-20 in.)
- 3 = 50-100 cm (20-40 in.)
- 4 = 100-150 cm (40-60 in.)
- 5 = >150 cm (>60 in.)

____ Available Water Holding Capacity
- 1 = 0-7 cm (very low)
- 2 = 7-14 cm (low)
- 3 = 14-20 cm (medium)
- 4 = >20 cm (high)

____ Infiltration Rate

____ Permeability
- 1 = Rapid
- 2 = Moderate
- 3 = Slow

Water Erosion Hazard ____
- 1 = Low
- 2 = Moderate
- 3 = High
- 4 = Very high

Wind Erosion Hazard ____
- 1 = None
- 2 = Moderate
- 3 = High

Internal Drainage ____
- 1 = Excessive
- 2 = Well
- 3 = Moderately well
- 4 = Somewhat poor
- 5 = Poor

Site Characteristics

____ Site Position
- 1 = Upland
- 2 = Footslopes or fans
- 3 = Floodplain
- 4 = Stream terrace or lake plain

____ Geologic Origin
- 1 = Residuum or colluvium
- 2 = Recent alluvium
- 3 = Old alluvium or lacustrine
- 4 = Wind blown sands or silts
- 5 = Volcanic ash
- 6 = 2 or more classes

Stoniness/Rockiness ____
- 1 = None
- 2 = Stony/rocky
- 3 = Very stony/rocky
- 4 = Extremely stony/rocky

Slope ____
- 1 = 0-3%
- 2 = 3-7%
- 3 = 7-12%
- 4 = 12-20%
- 5 = >20%

Management Interpretations

____ Drainage Feasibility
- 1 = Not needed
- 2 = Good
- 3 = Fair
- 4 = Poor

____ Irrigation Suitability
- 1 = Excellent
- 2 = Good
- 3 = Fair
- 4 = Poor
- 5 = Non-irrigable

____ Most Intensive Crop
- 1 = Row crop/Specialty crop
- 2 = Legume/hay
- 3 = Dryland wheat
- 4 = Permanent pasture
- 5 = Forest/range

Erosion Control Practice ____
- 1 = Channel control
- 2 = Cover crop
- 3 = Stubble mulch
- 4 = Diversion terraces
- 5 = Strip crop
- 6 = Controlled grazing
- 7 = Watershed management

Reaction Correction ____
- 1 = None
- 2 = Acidity
- 3 = Alkalinity

Limitations for Septic Tank Drainfields ____
- 1 = Slight
- 2 = Moderate
- 3 = Severe

TOTAL BACK ☐

INTERPRETATIONS FOR SCORE CARD

MOST INTENSIVE CROP

Irrigation Water Avail.

Row Crop/Specialty Crop
1. Soils W/Exc. or Good Irr. Suit.
2. Sandy soils w/Fair Irr. Suit.
3. Other soils w/Fair Irr. Suit. and 0-3%
4. Soils used for specialty crops
5. Exceptions: Coast, high elev., pH>8.4, unwise use

Legume/Hay
1. Non row-crop, but at least Fair Irr.
2. Include coast, high elev.
3. Poor Irr. Suit. if 12-20% only reason
4. Exclude soils with pH>8.4

Permanent Pasture/Grass Seed
1. Poor Irr. Suit. for reasons other than slope
2. Soils with pH>8.4

Irr. Water NOT Avail/Non-Irr.

Dryland Wheat
1. Fair or better irr. suit., but slope up to 35%
2. pH≤8.4
3.

Rainfall	Minimum AWHC (cm)
≥18	7
12-18	12.5
11	15
10	17.5
9	20
8	22.5
7	25

Permanent Pasture
1. Rainfall must be ≥18"
2. Poor Irr. Suit. for reasons other than slope
3. Non-Irr., up to 35%, if slope only reason

Forest
1. Rainfall must be ≥18"
2. Any soil >35%
3. Non-Irr. for reasons other than slope

Range
1. Rainfall must be <18"
2. Any soil not suited for wheat

EROSION CONTROL PRACTICE

Row Crop
1. Floodplains - cover crop
2. W. OR, 0-3% - channel control
3. W. OR, >3% - cover crop
4. E. OR, wind erosion - cover crop

Legume/Hay - channel control

Perm. Pasture, Range - controlled grazing

Dryland Wheat
1. W. OR, low erosion - channel control
2. W. OR, md or high erosion - stubble mulch
3. E. OR, Wind erosion - <10" rain - strip crop
4. E. OR, Wind erosion - >10" rain - stubble mulch
5. E. OR, Low or Mod. water erosion - stubble mulch
6. E. OR, High or V. High water erosion - diversions

Forest - watershed mgt.

SEPTIC TANK DRAINFIELDS

	Slight	Mod.	Severe
Eff. Depth (cm)	≥120	≥90	<90
Perm.	Mod.	Rap. or Mod.	Rap. to Slow
Drainage	WD	WD, MWD	Any
Slope (%)	0-7	0-12	>12
Site	All but Floodplain	All but Floodplain	Any

BOUNDARY (cm)	
Abrupt	<2.5
Clear	2.5 - 6
Gradual	6 - 12.5
Diffuse	>12.5

COARSE FRAGMENTS (%)	
<15	None
15-35	Grav/Cobb.
35-60	Very
>60	Ext.

AWHC (cm/cm)	
Sa, Lsa	.05
Sal, Sacl	.15
Sil, L, Sicl, Cl	.20
C, Sic, Sac	.15

INFILTRATION RATE

	Structure Grade			
Texture	None	Wk	Mod	Str
Sa, Lsa	Rap	Rap	Rap	Rap
L, Sil, Sal	Sl	Mod	Mod	Rap
Sicl, Cl, Sacl	Sl	Sl	Mod	Mod
C, Sic, Sac	Sl	Sl	Sl	Mod

PERMEABILITY

Sal, Lsa	Rapid
Sal, Sil, L	Mod-if porous Sl-if dense
Sacl, Cl, Sicl	Mod-if porous, or mod-str structure Sl-if dense, or wk-mass structure
C, Sic, Sac	Mod-if strong structure Sl-if wk-mod structure Vsl-if massive, dense

DRAINAGE FEASIBILITY

	Good	Fair	Poor
Restr. Layer (cm)	>120	>60	<60
Drain/Perm	MW/Sl	MW/Sl	MW/Sl
	SWP/Md	SWP/Sl	SWP/Sl
		PD/Md	PD/Sl
Outlets	Avail	Avail	Not Av.

WATER EROSION HAZARD

		Texture	
Slope	Infil	Sil, L, Cl, Sicl, Sacl	C, Sic, Sac Sal, Lsa, Sa
0-7	Mod	Low	Low
	Sl	Mod	Low
7-12*	Mod	Mod	Low
	Sl	High	Low
12-20*	Any	High	Mod
>20*	Any	V. High	High

*May be higher w/shallow restrictive layer

WIND EROSION HAZARD

	Texture	Hazard
W. OR	-	None
E. OR	Sil, L	Mod
	Sal, Sa	Sev
	Others	None

STONINESS/ROCKINESS

	None	Stny/Rcky	Very	Ext.
Stones (%)	<.01	.01-.1	.1-3	>3
Rocks (%)	<2	2-10	10-25	>25

IRRIGATION SUITABILITY

	Exc.	Good	Fair	Poor	Non-Irr
Slope/Infil.	0-3/Sl 3-7/Md	3-7/Sl 7-12/Md	7-12/Sl	12-20/Sl	>20
Eff. Depth (cm)	Unrest.	≥100	≥50	≥25	<25
AWHC	High	Mod	Low	V. Low	V. Low
Drain./Feas.	WD MWD/Gd SWP/Gd	WD MWD/Fair SWP/Fair	WD MWD SWP PD/Fair	Any	Any
Stony/Rocky	None	None	Stony/Rocky	Very	Ext.

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The Soil We Study

An Instructors Manual for
A Slide Set

September 1980

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Extension Soils Specialist

Oregon State University Extension Service

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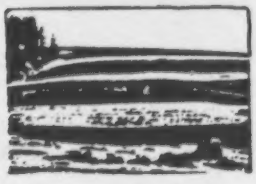
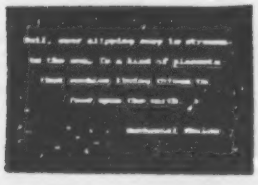
THE SOIL WE STUDY

1. Profile of Walla Walla silt loam (Typic Haploxeroll) from North-Central Oregon. It illustrates the fascinating world of soil revealed beneath one's feet by digging a soil pit or scraping off a road cut. Horizons are: A (0-11"), B (11-48"), C.

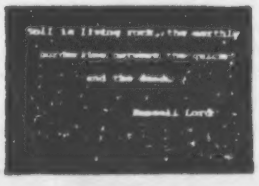
2. A rather oversimplied, but still very important definition of soil.



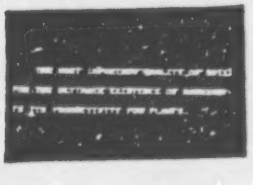
3. Illustration of soil's fundamental role as a medium for the growth of plants that provide the food supply for mankind. Picture shows contour wheat-fallow strips in Union County, near Elgin.



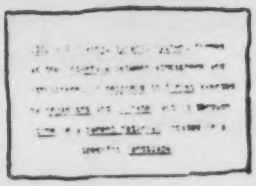
4. Nathaniel Shaler wrote this more poetic, but very forceful definition of soil in 1915, in a book entitled Man and the Earth.



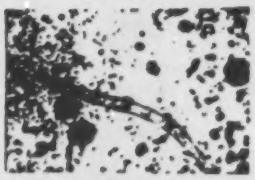
5. Russell Lord wrote this intriguing definition of soil in 1962 in a book entitled The Care of the Earth: A History of Husbandry.



6. Still another way to summarize why we should look closely at our soil resources and learn more about them is stated by Lord (1962) this way: "the fundamental problem of farming...is to handle soil not as an aggregation of inert rock materials but as the substance of life."

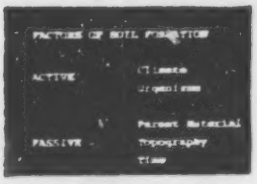


7. This is the working definition of soil used in Chapter 1 of the Manual for Judging Soils in Oregon. The significance of each underlined word or phrase is discussed briefly in the manual.

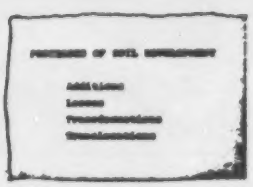


8. This slide illustrates the living, dynamic nature of the soil. A nematode (roughly horizontal) is being attacked by a fungus (very thin, nearly vertical strand). Both contribute to the accumulation of organic matter and the formation of humus in soils.

9. The active factors of soil formation, climate and organism, are the driving forces that cause change in the force-response relationship.



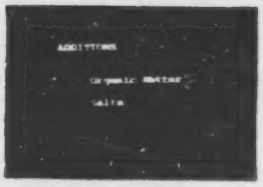
10. The passive factors respond to the driving forces by changing to form the organized system we know as soil. If there were 10 kinds of each factor, then there would be 10^5, or 100,000 different kinds of soil. In Oregon we know of about 800, in the U.S. 12,000.



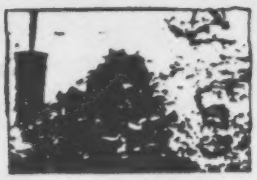
11. In addition to the 5 factors of soil formation, there are 4 major processes of change. Each process leaves distinctive marks on the profile of the soil that is formed.

12. One of the earliest forms of change in a fresh parent material is the addition of fresh leaves and twigs, invasions by micro- and macro-organisms, and accumulation of waste products of living things.

13. The effect of organic matter additions--in concert with decomposition of organic residues--is to darken the surface soil. Usually, the darker the color, the more the organic matter, and the richer the soil. This soil is a Prairie soil (Typic Argiudoll) in Iowa.



14. Soluble salts--sulfates and chlorides of Mg, Ca, Na--may be added in rainfall, dust, or by lateral movement through soil.

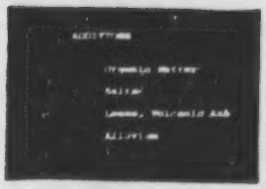


15. Here is a salt crust formed by evaporation of upward moving water in a salty soil in Baker County. Reddish-brown colors are caused by organic matter dispersed by sodium and deposited with the salts.

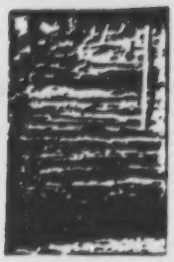
16. Loess and ash are additions of mineral material that are transported by wind. Loess consists primarily of silt and clay sized particles picked up by wind passing over glacial outwash plains.

17. Loess is most common in the midwest, in deposits that become thinner eastward from the Missouri and Mississippi rivers. Loess will maintain a vertical embankment, as in this bluff near Vicksburg, Miss. It is very erosive on slopes, however. In Oregon, loess occurs on uplands around Portland and from The Dalles to Pendleton.

18. This volcanic ash fell in Hawaii, but the recent fall from Mount St. Helens, had it been thicker, would have looked very much like it. If you look carefully, you can see three distinct layers of gray ash, representing three separate episodes of ash deposition.



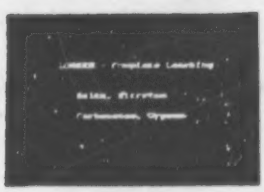
19. Alluvium is river-borne sediment that is deposited on a flood plain.



20. Here several episodes of alluvial deposition are evident. Each was separated by enough time to allow some accumulation of organic matter in the existing surface soil, causing the dark banding.

21. The freshness of this alluvial deposit is evident from the pools of standing water and the footprints in the newly deposited mud. The river is in the background, just beyond the tree line at the top of the slide.

22. Most losses occur when water, added either by rainfall or by irrigation, passes completely through the soil, carrying with it constituents dissolved on the way through. This process is called <u>leaching</u>. Salts and nitrates, being very soluble, are the first to be lost from a soil by leaching.



23. Carbonates (free lime) and sulfates (gypsum), though less soluble than salts, are nevertheless relatively quickly removed, as long as there is enough water to ensure complete leaching.

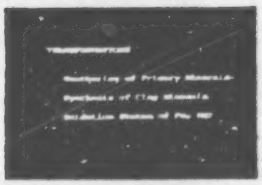
24. Silica includes a variety of crystalline and amorphous compounds made up primarily of silicon and oxygen. Silica is not very soluble at all, but over time even silica is slowly dissolved and leached. Some tropical soils have lost nearly all of their original silica.

25. Losses can also occur by physical removal of particles of soil, i.e., erosion. In severe cases, erosion may remove all the original topsoil, and a new surface horizon is forming in what was once subsoil.

26. Gully erosion, as in this midwestern feedlot, if unchecked can soon destroy a soil's productive capacity and render it incapable of supporting human existence.

27. Transformations are changes that take place within the soil. These are primarily chemical processes, and they may be either constructive or destructive. Hydrolysis of feldspars, micas, and ferro-magnesian minerals is the weathering process most responsible for destruction of primary minerals.

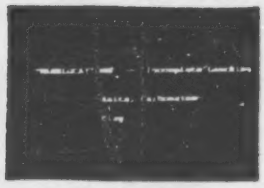
28. Most clay particles in soils are secondary minerals. As bonds are broken and compounds are destroyed by chemical weathering, some constituents are leached out, while others recombine to make new crystalline compounds--soil clay minerals.



29. In the absence of oxygen, iron and manganese accept electrons and are reduced. This makes them more mobile, and they are often translocated or leached out entirely. In aerated soils, Fe and Mn lose electrons and are oxidized, giving the soil a brown color.

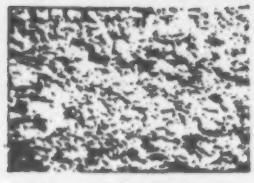
30. Translocations are movements of constituents from one part of the profile to another. If limited rainfall prevents complete leaching, salts and carbonates are dissolved from and moved out of the upper part of the soil, but are precipitated in horizons beneath the surface.

31. This Ustoll in eastern Colorado has lost carbonates from the upper 14 inches of soil, with a corresponding increase in the B3ca and C1ca horizons from 14 to 36 inches.

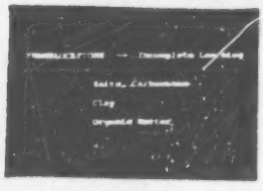


32. Translocations may also involve physical movement of fine clay particles from the upper to the lower part of the soil. Accumulation of clay in a subsoil contributes to the formation of a textural B (Bt), also called an argillic horizon.

33. The best evidence of clay translocation is a dark-colored waxy-looking deposit of clay on the walls of pores or on the surfaces of peds. These coatings are called clay skins.

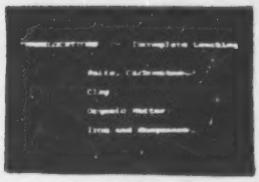


34. Careful inspection of the B horizon of this soil reveals darker colored splotches which are clay skins on the surfaces of the blocky peds. Clay and organic matter often move together, and the darkening is partly due to organic matter.

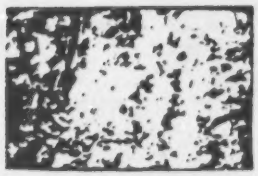


35. In some soils, organic matter may be physically translocated, or some of the organic matter may be dissolved and moved in solution or in combination with iron, aluminum, or clay.

36. This is a Haplaquod from Florida. It is a poorly drained sandy soil under coniferous vegetation. Acid leaching has dissolved and translocated organic matter; the black horizon below the white one is the result of organic matter deposition following translocation.

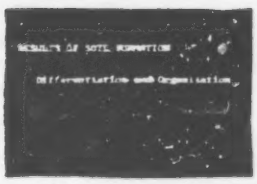


37. When iron and manganese are reduced they are mobile, and are often translocated. When oxidized, they are virtually insoluble. Repeated cycles of wetting and drying cause repeated translocation and precipitation of iron and manganese compunds.



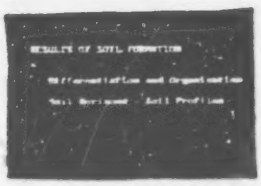
38. The gray soil has been stripped of iron coatings during periods of reduction. The color is due to the color of quartz grains. Translocated iron has been deposited around a root channel (upper left), where oxygen first enters forming a pipestem. Other mottles throughout the horizon are formed similarly.

39. Iron can also move in certain well-drained soils. Sandy soils under coniferous trees are very acid. Both organic matter and iron are mobile and move together. Iron has been removed from the white A2 above 1 foot and redeposited in the Bir between 12 and 18 inches.

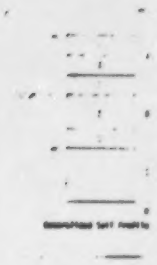


40. The processes of soil formation create a well-organized system which we call soil. Soil is different from pulverized rock debris, partly because of the influence of organic matter, and partly because it is differentiated into soil horizons.

41. One way to express the organized system concept is with this simple diagram. Soil is approximately 50% solids and 50% voids. Solids are mostly mineral particles, with up to 5% by weight organic matter. Voids are filled with fluctuating proportions of air and water.



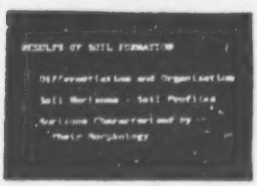
42. Processes of soil formation differentiate parent material into a series of horizons. Together the vertical sequence of horizons constitute the soil profile.



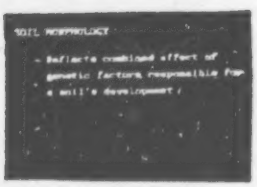
43. The generalized soil profile illustrates the relationships among the major kinds of A, B, and C horizons. Note that the sum of all A and B horizons present constitute the soil solum.

44. The horizons in some soil profiles are very distinct, as in this wet, sandy soil in Florida. Iron and organic matter have been translocated out of the white A and into the black B. The C horizon is mottled.

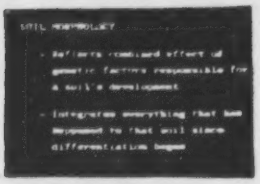
45. Other soils, like this Jory soil in western Oregon, have very indistinct horizons. Careful examination, utilizing mainly the sense of touch to determine texture and structure, is needed to separate one horizon from another.



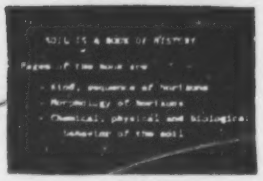
46. Each soil horizon, and thus the entire profile, is characterized by its morphology. Strictly speaking, that means the science of form, or shape. We broaden it to include all of the observable properties of a soil, like color, texture, structure, consistence, roots, pores, boundaries, etc.



47. Each horizon has a particular morphology because of the unique interactions among all five factors of formation and all four general processes of soil development.



48. Soil morphology thus provides a record, or a signature, that tells us what has happened during the course of soil development. In this sense, the soil profile can be thought of as a book of history.



49. By carefully reading the book, we can not only infer what has happened to the soil, but what will happen if we manipulate the soil for agricultural production. Soil judging, then, is learning how to read the book to better understand how to use and manage this valuable resource.

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Kinds of Soil Horizons

An Instructors Manual for
A Slide Set

September 1980

J. H. Huddleston
Extension Soils Specialist

Oregon State University Extension Service

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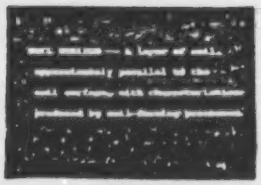
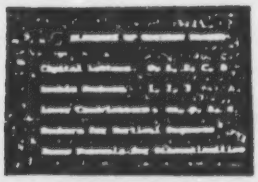
KINDS OF SOIL HORIZONS

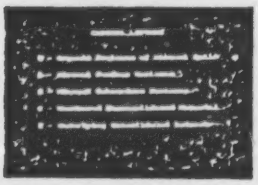


1. What is a soil horizon? The soil forming processes that produce them are the additions, losses, transformations, and translocations discussed in Chapter 1. These in turn are influenced by the five soil-forming factors.

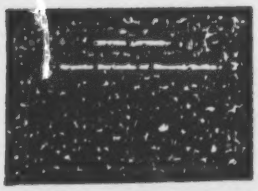
2. This profile of an Alfisol in Michigan clearly shows a sequence of horizons formed by addition of organic matter (A1 - 0 to 10"), leaching of clay (A2 - 10 to 18"), and accumulation of clay (B2t - 18 to 42"). Prismatic structure and clay skins are evident in the B2t.



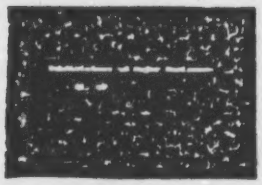
3. Most major kinds of horizons are named by combining a capital letter with an arabic number. Sometimes lower case letters are used to further specify the kind of horizon. Additional numbers may be used to subdivide thick horizons or to indicate more than one kind of geologic material.



4. These are the 5 basic categories of horizons as designated by capital letters. There are 2 or 3 major kinds of O, A, and B horizons, however, These will be illustrated in the following slides.



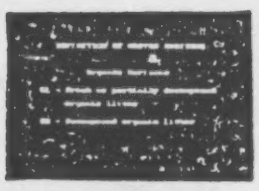
5. O horizons consist almost entirely of organic matter--litter and humus--resting on top of the surface of mineral soils.



6. There are two kinds of O horizons. The distinction between them depends on the extent of decomposition of the organic matter.

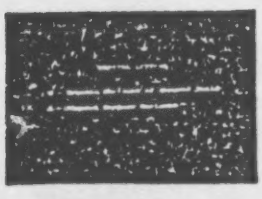
7. The O1 horizon consists of fresh or slightly decomposed litter on top of a mineral forest soil. Individual leaves and twigs can still be identified.

8. This soil in Josephine County has a very thin O1 layer that consists mostly of dead leaves.



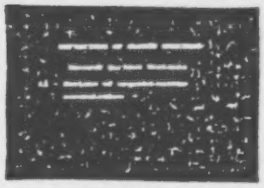
9. Organic matter in the O2 is so thoroughly decomposed that original species can no longer be identified.

10. This Spodosol (Typic Haplorthod) from New York has both an O1 and an O2 on top of the white A2 horizon. Note that the reference point for measuring soil depths is at the base of the organic horizons, i.e., at the top of the mineral soil. Other horizons present include a thin Bh (11-12"), B2ir (12-17") and C.



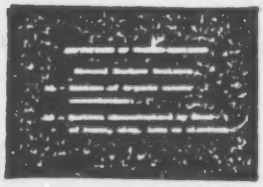
11. A horizons form at or near the surface of mineral soils.

12. There are three major kinds of A horizons. Each one has its own definition and represents the effects of different kinds of soil-forming processes.



13. As soon as plants begin to grow, organic matter begins to accumulate within the surface horizon. Plant roots that die are decomposed in place, and worms and other soil animals mix litter into the mineral soil. The total amount of organic matter in the Al, however, is almost always less than 5% by weight.

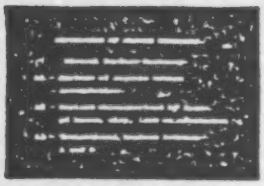
14. Enrichment with organic matter causes darkening of the Al. Usually the darker the color, the more the organic matter, and the richer the soil. This Mollisol (Typic Argiudoll) in Iowa has a thick Al (18") due to the accumulation of decayed grass roots.



15. The A2 horizon is very different from the Al. It is light-colored because of the loss of organic matter, or of brown coatings of iron oxide, or both. It is a highly leached horizon, and often has lost clay as well.

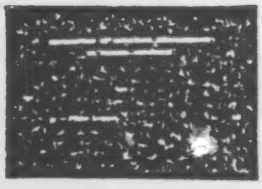
16. This is another Spodosol from New York that has an 02 horizon directly above the white A2 horizon. There is mp Al. It is a very acid soil, and both organic matter and iron oxide have been translocated out of the A2 and into the B. The white color is due to uncoated quartz grains. This soil also has a B21r from 14 to 19 inches.

17. Here's another A2 in a poorly drained Mollisol from South Dakota. There's an Al above it and a B2t below. The B2t is clayey and very slowly permeable. Water is forced to move laterally, leaching organic matter and iron oxide out of the horizon.



18. Many soils do not have vivid horizons with abrupt boundaries between them. Instead there is a gradual change from one horizon to another. A transitional zone which still retains most of the properties of an A horizon, but also has some characteristics of a B, is called an A3.

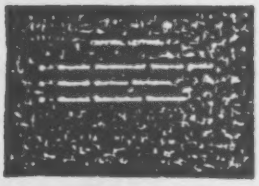
19. This Monona soil (Mollisol) from Nebraska has an A1 horizon about a foot thick. The next horizon, from 12 to 18", is an A3. It is still dominated by accumulation of organic matter, but the color is fading (and so is the amount of O.M.), and the structure is probably becoming blocky.



20. The Ap horizon is the surface 8 to 10 inches of soil thoroughly homogenized by cultivation. Any former A1, A2 or even B horizons that may have existed within that depth are destroyed and mixed together. Any cultivated soil will always have an Ap.

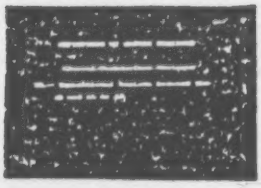
21. One good indicator of a plow layer is an abrupt, smooth boundary at the base of the Ap. This Ap rests directly on a B2 horizon. In many soils the base of the Ap will also have platy structure, created by many episodes of shearing and smearing by the plow. This is called a plow sole, plow pan, or tillage pan.

22. The plow layer may show the effects of soil erosion. The Ap in dark areas is entirely within the A1. On more eroded slopes, most of the A1 is gone, and the plow layer incorporates mostly light-colored A2 material. On severely eroded areas, the plow reaches into the yellowish-brown B. This landscape is in Indiana.



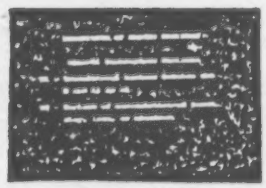
23. B horizons form below A horizons in mineral soils. They are the result of different kinds of processes, and they are as rich and varied as the diversity in the processes themselves.

24. As with the A horizons, there are three major kinds of B horizons. Their definitions, nowever, do <u>not</u> parallel the definitions of the A horizons.



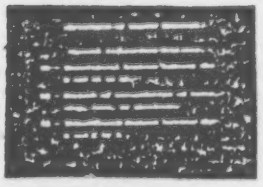
25. Like the A3, the B1 horizon represents a zone of transition between the A and the B. Unlike the A3, the B1 has characteristics mostly like those of the B2 below, but retains some of the characteristics of the A.

26. In this Woodburn soil (Aquultic Argixeroll) from Marion County, the horizon immediately below the knife is the B1. It is about 7 or 8 inches thick. Above it is an Ap. Below it is a B2t. Visual indistinctness of horizons is typical for this and many other soils.



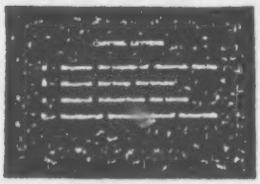
27. The subsurface horizon that exhibits the maximum imprint of soil-forming processes is the B2. There are many kinds of B2 horizons, and many possible degrees of expression of "maximum."

28. This soil, a Calciorthid from Idaho, has a cambic B, which is labeled simply B2. It is the brown horizon. "Maximum" in this case means nothing more than leaching out the free lime and developing a little color and structure. The white horizon is a Cca.



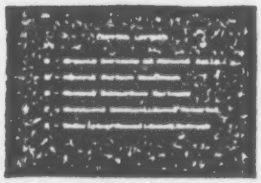
29. The B3 is another transitional horizon. It represents the zone of gradual change away from the maximum development in the B2. Often clay content decreases in the B3, and structure becomes coarser and weaker.

30. The horizon sequence in this Ultisol from Arkansas is A1-A2-B2t-B3t. The B3 begins at about 30 inches, where the red color begins to fade and lighter colors more like the C begin to appear. The horizon still has blocky structure, however.



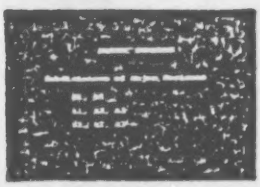
31. The C horizon is not a part of the developed soil, or solum. Rather it is unconsolidated material beneath the B that has been geologically weathered but is little affected by other soil-forming processes.

32. The horizon sequence in this Spodosol from Minnesota is O1-O2-A2-B2ir-C. The C horizon is the grayish horizon from about 14 inches on down. Irregularity in the shape of horizon boundaries is due to the effects of tree-throw.

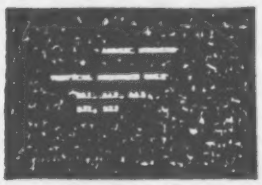


33. R stands for hard bedrock, like basalt or andesite. Technically, it has a hardness of 3 or more on the Mohs scale.

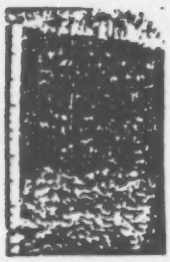
34. About all you could say about this soil is that it has an extremely stony A1 horizon that rests directly on an R horizon.



35. This slide reviews the major kinds of soil horizons, named by a specific combination of a capital letter with an arabic number Each of the 8 horizons listed has its own specific definition and mode of formation.

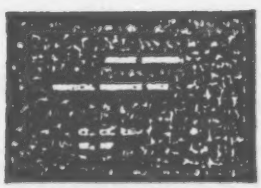


36. Some A and B horizons are very thick. It is convenient to subdivide them into 2 or 3 parts based on some small change in color, texture, structure or other property. This is done by adding a second number to the master horizon name to indicate its position in a vertical sequence. Read as A-one-one, A-one-two, A-one-three, etc.

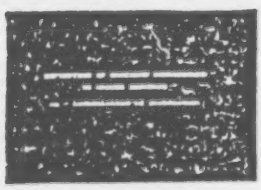


37. This pooly drained Mollisol in Iowa has a very thick A1. Chances are the upper 10 inches or so is an Ap. The soil from 10 to 20 inches is an A12. From 20 to 30 inches is an A13.

38. This deeply weathered tropical soil from Puerto Rico has a very thick B2 horizon. The horizon from 12-21" is a B21, and the horizon from 21-30" is a B22. Next in sequence are a B3 and a C.

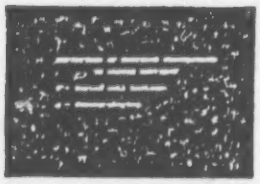


39. Arabic numbers associated with C and R horizons indicate nothing more than vertical sequence. C1, C2, and C3 all have the same basic definition of the C horizon.

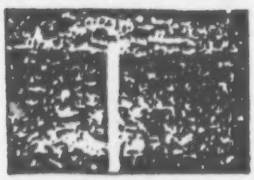


40. Certain soil-forming processes create special features that may be found in several kinds of master horizons. These are indicated by adding lower case letters to the horizon name. In arid soils, B2ca, B3ca, and Cca all indicate that the horizon has an accumulation of calcium carbonate, or free lime.

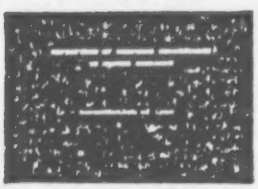
41. In this Aridisol from Arizona there is a desert pavement underlain by a thin A1 (0-2"), B2 (2-9"), B31ca (9-18"), B32ca (18-30") and Cca (>30"). The white streaks are free lime leached out of the A and B2 and redeposited in the B3. the ruler is 18 inches long.



42. A small g indicates the horizon is gleyed. Gleyed horizons are wet much of the time, so that iron oxides are first reduced then leached out. The resultant color is gray. Gleyed horizons may or may not be mottled. Any A, B, or C horizon may be gleyed.

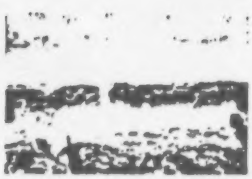


43. This is a poorly drained Mollisol from Rumania. The horizons are A11 (0-6"), A12 (6-14"), B21g (14-21") and B22g (21-26"). Mottling in the B21g indicates fluctuating water tables, allowing periodic oxidation. Lack of mottles in the B22g suggests nearly permanent saturation.

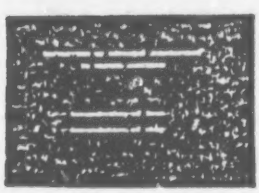


44. The letters ir stand for iron, or iron oxide. They are used specifically for a B2 horizon that has an accumulation of iron oxide, which is usually associated with organic matter as well.

45. The horizon sequence in this Spodosol from New York is O2, A2, thin black B2h, B2ir, and B3. The B2ir is most common in sandy soils under pine or spruce vegetation. Very acid leaching causes organic matter, iron, and aluminum all to move together out of the A and into the B. Some of our Oregon coastal soils have B2ir horizons.

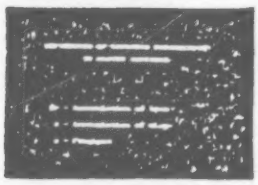


46. This B2ir formed in a sandy soil in Florida. Note the thick A2. Duller colors in the B2ir, and a thicker zone of humus enrichment (B2h) both indicate a poorly drained soil, despite the sandy texture.



47. Little t stands for texture: it indicates that the horizon has been modified by accumulation of clay. This occurs only in B horizons, especially the B2t, which is called a textural B, or argillic horizon.

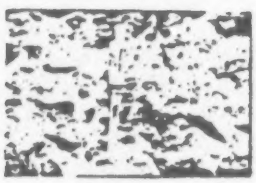
48. The argillic horizon in this Alfisol from Iowa begins at about 18 inches, right below the A2. Argillic horizons commonly have moderate or strong structure and dark waxy coatings called clay skins. Prismatic structure is clearly evident in this profile.



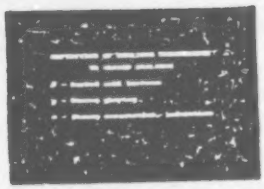
49. A special feature found in Oregon only in the Portland area is the fragipan, designated with an x. Fragipans are firm, dense layers that are not cemented, but do limit root penetration and water permeability. Fragipans may occur as Bx or Cx horizons.

50. This is a very dense fragipan in a New York soil. The pan begins at about 15 inches, where the knife is. Note its massive structure. The white layer above is an A2. It has been leached by water moving laterally above the slowly permeable fragipan.

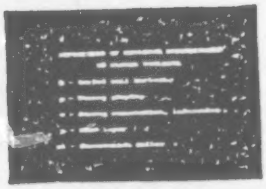
51. The fragipan in this Grenada soil from Tennessee begins at about 18 inches, right below the A2. A characteristic feature shown in this slide is the gray streaks of silt within the pan.



52. This is a closeup of the fragipan in the Cascade series (Typic Fragiumbrept) near Portland. Note again the massive soil within very coarse prisms bounded by gray silt streaks.

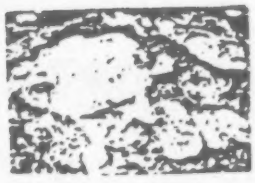


53. The letter m always means that a horizon is cemented, or indurated. There are several degrees of cementation, but strongly cemented horizons are in essence just like bedrock layers.

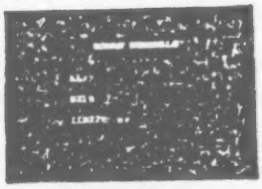


54. A common cementing agent in eastern Oregon is silica. Many of those soils contain volcanic ash high in amorphous silica, which can be moved downward and deposited in lower horizons. A horizon cemented with silica is called a duripan. It is designated either as C_{sim} or C_{casim}.

55. This is a Minidoka soil (Xerollic Durargid) from Idaho. The strongly cemented duripan is the horizon from 16 to 22 inches. It is a physical barrier to both roots and water. Sometimes the duripan can be ripped to allow roots to penetrate the pan and utilize the uncemented soil beneath.



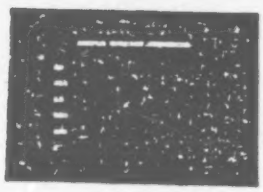
56. Under limited rainfall, water only partly leaches the soil. Here, deposits of lime and silica have formed on the under side of pebbles and cobbles, where drops of water evaporated, leaving behind the lime and silica that was in solution. This is how duripans become cemented.



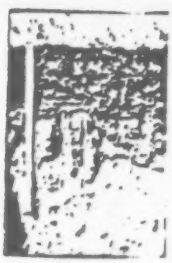
57. Roman numerals are used in some horizon names to indicate the presence of two or more different kinds of geologic material. In this slide the II indicates that the B22t has formed in a material quite different from that in which the A1 and B21t formed.

58. Here are two different deposits of glacial till in Wisconsin. Horizons in the brown cobbly till would all be preceded by the roman numeral II. The numeral I is never written, but is simply understood to apply to horizons in the red, clayey till.

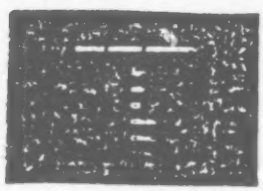
59. This slide shows 3 layers of gray ash over residuum in Hawaii. The probable horizon sequence here is A1-IIC1-IIIC2-IVC3, the last being the brown residuum. Even though the first three horizons are all ash, roman numerals are used to indicate three distinct episodes of deposition.



60. In a typical horizon sequence such as this, we can tell immediately that the soil has a thick A1, the upper part of which is plowed. The A1 changes gradually through an A3 to an argillic, or textural B horizon, which in turn merges gradually into unconsolidated material of the C.

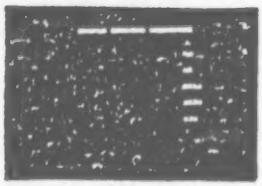


61. This Mollisol from Nebraska illutrates the horizon sequence in the previous slide. Note the A3 between 17 and 22", strong prismatic structure in the B2t, and the weaker structure in the B3t from 3 to 4 feet.



62. This horizon sequence suggests a weakly developed soil--there's no B horizon--in a semi-arid climate--because of the duripan and the Cca.

63. The Hutchinson soil (Argic Durixeroll) in Union County resembles the horizon sequence above. The duripan is evident below the knife tip, and the light-colored soil beneath it contains free lime. The Ap is also apparent, but the brown horizon below it is actually a B2t.



64. This sequence suggests a thick B horizon with relatively thin, distinct A horizons above it. The soil must be older, in order for weathering and soil formation to develop such a thick argillic horizon.

65. Sure enough, we have a Typic Hapludult from North Carolina. The A1 is thin and light-colored, suggesting low organic matter. The A2 is prominent, and the B2t is about 2 feet thick.

The Soil Sample Should be Carefully Mixed and Packaged

- Soil sub-samples should be placed in a clean container and mixed thoroughly.
- The soil sample bag is filled with the soil mixture.

Special Soil Sampling Techniques Are Sometimes Required for:

- Some crops such as established orchards.
- Some nutrients such as nitrate nitrogen. Nitrate nitrogen soil tests are recommended only for a limited number of crops in eastern Oregon.
- Special soil sampling techniques are described in other publications or instructions.

Forwarding the Soil Sample

- Print the necessary information on the sample bag. Be sure to number each sample and keep a record on the fields sampled.
- Don't use paper bag for soil sample.
- Fill out information sheet and mail it at the same time the sample is mailed.

- Include a check to cover the cost of the soil test with the information sheet.
- Wrap sample securely and mail to:

SOIL TESTING LABORATORY
OREGON STATE UNIVERSITY
CORVALLIS, OREGON 97331

Soil sample bags, sampling instructions, and soil sample information sheets are available from your Extension agent.

- Soil test results are sent to your County Extension Agent who makes the fertilizer and liming suggestions. The suggestions are based on the results of fertilizer experiments, soil surveys, and results obtained by farmers.

HOW OFTEN SHOULD SOILS BE TESTED?

- For perennial crops such as alfalfa, grass seed, and permanent pasture soils should be tested prior to seeding and subsequently at least every 3 years. The initial soil test, prior to seeding, is particularly important.
- For annual crops the soil should be tested annually before planting.
- Soil testing well in advance of planting is important particularly in the case of acid soils where liming is likely to be needed. Lime should be applied and mixed with the soil several months prior to seeding as lime reacts slowly with the soil.

Prepared by E. Hugh Gardner, Extension soil science specialist, Oregon State University, Corvallis.

Extension Service, Oregon State University, Corvallis, Henry A. Wadsworth, director. This publication was produced and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. Extension work is a cooperative program of Oregon State University, the U. S. Department of Agriculture, and Oregon counties. Extension invites participation in its programs and offers them equally to all people, without discrimination.

How to take a

Soil Sample

. . . and why

Oregon State University
Extension Service

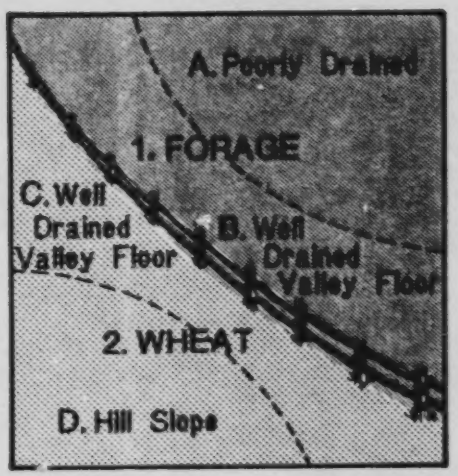
Extension Circular 628 • Reprinted May 1981

Ag II - IV - 210

IN Oregon, soil tests such as those conducted in the OSU soil testing laboratory will help you to develop and maintain a more productive soil and to increase net returns per acre by providing information on the available nutrient content and fertility status of the soil. This helps you to select the correct kind and amount of fertilizer and liming material.

A soil sample weighing approximately ½ pound is used to represent from 2 to 40 million pounds of soil in the field. Thus care in soil sampling is essential.

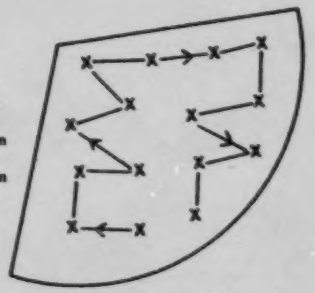
Each Soil Sample Should Represent Only One Soil Type or Soil Condition



Different soil types should be sampled separately. Thus A, B, and D should be sampled separately. Areas such as 1 and 2, with different management histories, should be sampled separately. In this example a separate soil sample should be taken from each of the four following sampling areas: 1A—Forage on poorly drained soil. 1B—Forage on well drained valley floor soil. 2C—Wheat on well drained valley floor soil. 2D—Wheat on hill slope soil.

A Good Soil Sample Should Represent the Area

- Each sample should consist of subsamples (X) taken from 15 to 20 locations within the sampling area.



- Where fertilizer has previously been banded, as for vegetable crops, take at least 30 to 40 subsamples. Do not take subsamples from fertilizer bands where these can be identified.

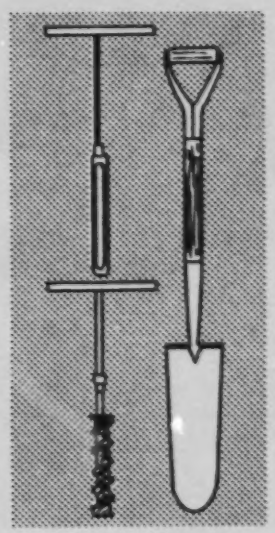
Small, Unusual Areas Should Be Avoided

- Take separate soil samples from unusual areas which are large enough to fertilize separately.

Take Soil Sample to the Correct Depth

- Unless otherwise specified, soil samples are taken to plow depth—usually from the surface down to about 6 to 9 inches.
- When deeper soil samples are required, they are removed from the bottom of the holes from which the surface sample was taken.

Avoid Contaminating the Sample



- Use clean sampling tools.
- Avoid contaminating the sample during mixing or packaging.
- A small amount of fertilizer residue on tools or hands, for instance, can cause serious contamination of the soil sample.
- Galvanized, brass, or bronze sampling tools should not be used for soil samples where a soil test for micronutrients such as zinc is to be run.

ANIMAL NUTRITION

Instructor's Guide

1. The materials provided in this unit are taken primarily from materials available from Vocational Instructional Services, Texas A & M, College Station, Texas.
2. Specific objectives for this unit are compiled at the beginning of the unit so that they may be duplicated and provided to students.
3. Transparency Masters will be found at the end of specific topic areas.
4. Worksheet assignments are provided for "Rations" at the end of that topic area.
5. Example quizzes are at the end of the unit. Instructors should review and revise the quizzes to make them compatible with the material presented in class and in handouts.

Objectives

Upon completion of this unit, the student will be able to:

1. Distinguish between a simple and compound stomach.
2. Classify animals according to their types of digestive systems.
3. Label drawings of parts of the digestive tract of cow, pig, and chicken.
4. Describe the digestive process.
5. Name the six classes of nutrients.
6. Distinguish between plant and animal protein.
7. Match nutrients with their function.
8. Categorize vitamins according to water soluble and fat soluble.
9. Classify common concentrates.
10. Classify common roughages.
11. Name three feed additives.
12. Explain the function of antibiotics in feed.
13. Explain the function of hormones in feed.
14. Define digestion and absorption.
15. Explain the role of enzymes in digestion.
16. Define ration and balanced ration.
17. Compare Composition of D.P. and TDN in common feedstuffs.
18. Compare feeds on the basis of cost per pound of TDN.
19. Compare cost per pound of protein.
20. Use tables in Morrison's "Feeds and Feeding" to determine nutrient requirements and composition of feeds.

21. Compute ration by Pearson Square.
22. Balance a ration by the TDN method.
23. Define common terms associated with animal nutritions.

Student Activities

1. Read objective sheets.
2. Read information sheets.
3. Complete worksheet assignments.
4. Take unit exams and/or quizzes as identified by instructor.

Teaching Aids

1. Objective sheets.
2. Information sheets.
3. List of terms and definitions.
4. Transparency Masters (Numbered by Topic Area).

(Topic 1)
#1 Digestive System of the Swine.
#2 Digestive System of the Cow.
#3 Digestive System of the Chicken.

(Topic 2)
#1 Composition of Animals' Bodies.
#2 Fat and Water Soluble Vitamins.
#3 A Daily Water Consumption Guide for Animals.

(Topic 3)
#1 Classification of Concentrates.
#2 Classification of Roughages.

(Topic 4)
#1 Three Routes of Feedstuffs in Ruminants.
#2 Digestive Systems of the Swine.
#3 Digestive System of the Chicken.

(Topic 5)
#1 Essentials of a Good Ration.
#2 Essential and Non-Essential Amino Acids for Swine.
#3 Nutritive Requirements for Chickens.
#4 Comparison of the Value of Corn and Milo Based on TDN.
#5 Grain Substitution for Comparison Chart.
#6 Commercial Feed Tag (Label Example)
#7 Nutritive Requirements for a 600 lb. Baby beef.
#8 Sample ration for a 600 lb. Baby beef.
#9 Determining Nutritional Requirements for a Dairy Cow.
#10 Using the Square to figure Rations.
#11 Using the Square to Figure a Ration for a 600 lb. Wintering Beef Heifer.
#12 Using the Square to Figure a Complete Ration.

5. Assignment Sheets (at end of Topic 6).

#1 Determining TDN and DP Content of Basic Feeds.
#2 Balancing Rations Using Pearson's Square.
#3 Working a Sample Ration for a Fattening Beef Animal.
#4 Working a Sample Ration for a Fattening Swine.

6. Answers to Assignment Sheets.
7. Sample Quizzes.
8. Answers to Sample Quizzes.

References

1. Feeds and Feeding, Frank B. Morrison, The Morrison Publishing Company, Clinton, Iowa.
2. Feeds and Nutrition, Abridged, Ensminger & Olentine, Ensminger Publishing Company, Clovis, California, 1978.
3. Modern Livestock and Poultry Production, Gillespie, Delmar Publishers, Albany, New York, 1981.
4. The Stockman's Handbook, Ensminger, Interstate Printers & Publishers, Inc., Danville, Illinois, 1978.

Common Terms and Definitions

1. Nutrient - The part of the feed which supplies building materials and energy fuel for animals.
2. Total digestible nutrients (TDN) - The proportion of a feed which is usable to supply energy to animals.
3. Feed additives - The substances added to a ration to perform a specified function.
4. Protein - The nutrient which supplies building materials for body growth and repair, organic compounds consisting of C, H, O, N, and S, and sometimes P & Fe.
5. Digestible protein (DP) - The proportion of a feed which represents protein the animal can use.
6. Starch - A carbohydrate which supplies energy to animals.
7. Vitamins - The complex chemicals essential for normal body functions.
8. Minerals - The elements which are necessary for proper body functions and life processes.
9. Amino acids - The building blocks of protein.
10. Antibiotics - The substances used in small amounts to help prevent and control certain diseases in animals.
11. Urea - A synthetic protein substitute used in a ruminant's ration.
12. Roughage - The feeds high in fiber and low in digestible nutrients.
13. Silage - The feed crops cured and stored green or without drying.
14. Concentrates - The feeds which have a high proportion of digestible nutrients and not much fiber.
15. Ration - The daily feed which an animal receives.
16. Balanced ration - A ration which contains the nutrients in the amount and proportion needed by an animal.
17. Fiber - The tough part of feed which is not very digestible.
18. Supplement - Anything which is added to a feed.
19. Pasturage - The plant growth available to animals on the range or in the pasture.
20. Fats - The organic compounds composed of C, H, and O.
21. Dry Matter (DM) - The average percentage of dry matter in feed found by weighing the feed then drying and re-weighing.
22. Digestion - The process of preparing the food ingredients for passage into the blood stream.
23. Absorption - The passing of food materials from the digestive tube into the body after they are digested or dissolved.

24. Enzymes - The organic compounds with power to break down other organic compounds without themselves' being changed.
25. Hormones - The internal body secretions that regulate various body processes.
26. Mastication - The grinding or chewing of feed to aid in digestion.
27. Metabolism - The chemical change which food undergoes within the body.
28. Excretion - The removal of water and waste material from the body.
29. Regurgitation - The process whereby food eaten by ruminants is carried from the second stomach and the rumen into the gullet and then forced up to the mouth for chewing.
30. Feces - The manure or the undigested material and wastes expelled at the end of the digestive tube.
31. Pancreatic juice - The clear, watery fluid with an alkaline reaction secreted by the pancreas that aids in feed break-down.
32. Bile - The thin, yellowish-brown or greenish liquid secreted by the liver.
33. Ruminant animal - The animal with four compartments in the stomach.
34. Alimentary tract - Passage in the body that feed (food) goes through.
35. Synthesized - The formation of a complex chemical compound by the combining of two or more simpler compounds or elements.

Topic 1: Digestive System

*Terms: All terms underlined are included in the "Glossary of Terms".

1. Importance of the Digestive System

Farm animals have two distinct types of digestive systems. These are ruminants (cud-chewing animals such as cattle, sheep, and goats) and monogastric animals (animals having simple stomachs). Animals with this type of digestive system are horses, swine, and chickens.

Differences of the two systems are as follows:
1. Ruminants have relatively large digestive systems which enable them to consume larger amounts of roughages than animals with simple stomachs,
2. Ruminants have a much greater ability than nonruminants to digest roughage before it enters the intestinal tract, and
3. The alimentary tract of ruminants is much more efficient than nonruminants in the utilization of crude fibers.

The major functions of the digestive system are the storing of food for a short time, preparing the food for absorption, assimilating of the used products in the food, and the rejecting of the undigested and unabsorbed portions of food.

The organs contained in the digestive system may be grouped into two categories:

1. Alimentary tract (canal) - The canal may be described as a tube which extends from the lip to the anus. The digestive processes take place in the canal. The walls of the canal are covered with voluntary muscles which mix the food with digestive juices and move the food along the digestive tract. The parts of the alimentary canal are the mouth, pharnyx (or throat), esophagus, stomach, small intestine, large intestine, and anus.
2. Accessory organs - These are the organs that aid the digestive tract with the receiving and digestion of food. Included in this category are the teeth, tongue, salivary glands, liver, and pancreas.

2. Functions of the Digestive Organs

The first part of the alimentary canal to function is the mouth, which is used for the intake of food and mastication (chewing). This is the beginning of digestion. During the chewing process saliva is secreted in the mouth by the salivary glands and is mixed with the food.

The pharnyx (throat), a muscle membrane sac common to both the digestive and respiratory tract, serves as a passage for food going from the mouth to the esophagus and air going to the lungs.

The esophagus is a long muscular tube which is used as a passage for food going from the pharynx to the stomach.

Transparency No. 1

In animals with simple stomachs, the stomach is a large dilation of the alimentary canal behind the diaphragm. This is the first reaction chamber. Specialized cells located in the walls of the stomach produce hydrochloric acid and secrete gastric (stomach) enzymes. The digestion of food, carbohydrates, and fats and the beginning of the digestion of proteins take place in the stomach.

Food from the stomach passes into the small intestine. This intestine is a complex tube which lies in a spiral and is as long as 130 feet in some animals. More digestive juices and enzymes are added in this area, digestion is continued, and digestible food is absorbed by the blood.

The caecum is located at the junction of the small and large intestine. In some animals the caecum is small and has little function; however, it is very important in animals such as horses and rabbits. Another function of the large intestine is to add mucus material to the remaining food. This is a lubricant that makes passage through the tract easier.

The anus or rectum is the last part of the digestive tract. The undigested portion of the food taken in the mouth is eliminated here.

Transparency No. 2

The complex stomachs of ruminants are composed of four compartments, the rumen, reticulum, omasum, and abomasum. The rumen is the first and largest compartment and serves as storage for large amounts of feed. Bacteria in the rumen change non-digestible nitrogenous substances into a digestible form which is synthesized (made into) into protein and used by the animal.

The feed eaten by ruminants is regurgitated and rechewed; this is commonly known as chewing the cud.

The reticulum, being forward in relation to the other compartments of the stomach, is closely related to the rumen. This portion of the stomach, is closely related to the rumen. This portion of the stomach retains foreign materials that could harm or damage other parts of the digestive system. The third compartment or omasum squeezes the liquid out of the feed before it enters the abomasum. In the abomasum, or true stomach, gastric juices are released to continue digestion. The food passes from the true stomach to the small intestine where the digested food is absorbed by the blood.

The non-absorbed material passes from the small intestine into the large intestine where digestion and absorption continue.

The caecum is next. The bacteria in the caecum transform the non-digestible nitrogenous substance into digestible protein which is absorbed and utilized by the body. From the caecum, the waste material passes into the colon where it is expelled from the animal's body.

3. Functions of the Accessory Organs

The teeth serve in the mastication or grinding of feed.

The tongue turns and rolls the feed as it is chewed. The tongue contains taste buds used by the animal for tasting.

The salivary glands secrete saliva into the mouth to begin digestion, and it moistens feed before it is swallowed. The primary feed component which saliva begins to digest are the starches. Starches must be brokendown to sugars so the animal may use them as an energy source.

The liver secretes bile into the small intestine, which with the pancreatic juices neutralizes the acidity of the feed after it leaves the stomach, and allows enzyme action to occur. Bile also aids in the breakdown of fats to fatty acids, fatty acids can then be absorbed and used by the animal.

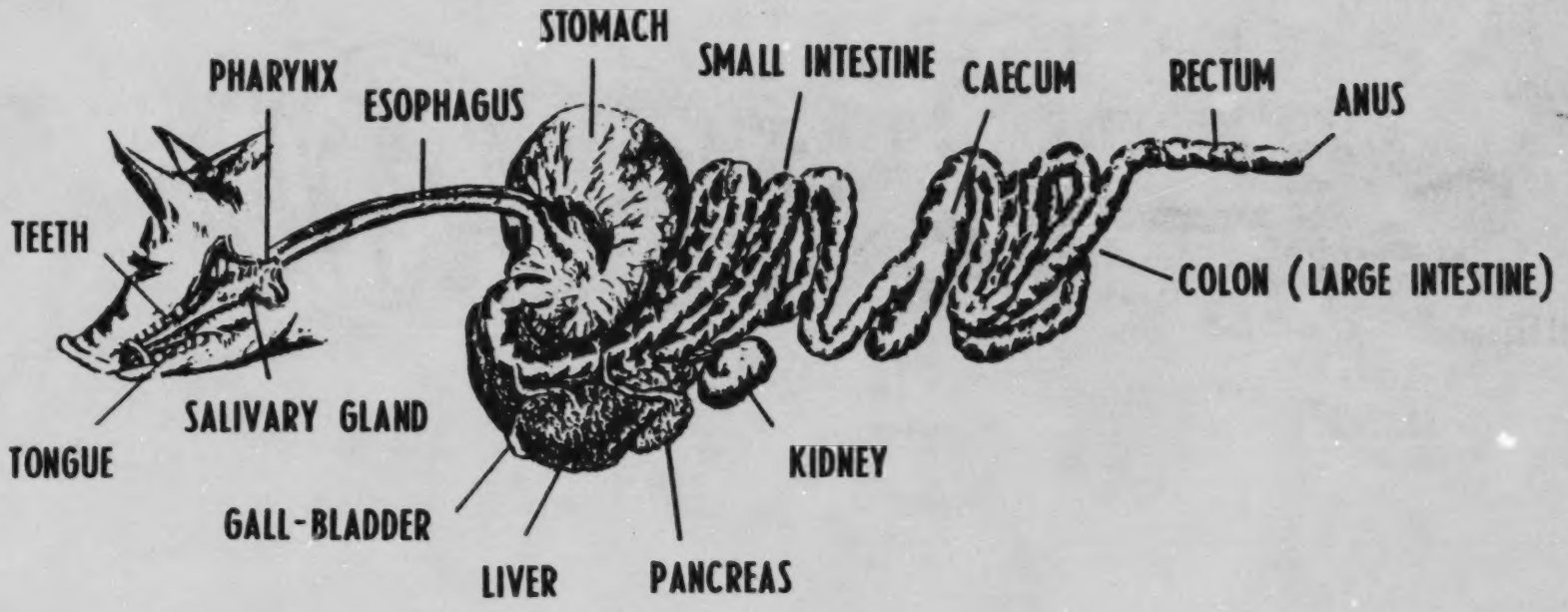
The pancreas supplies pancreatic juices to the small intestine, aids in digestion, and neutralizes the acidity of the feed after itleaves the stomach.

4. Digestion in Poultry

Transparency No. 3

The digestive system of poultry is not classified as a simple stomach, but it is very similar to that of the simple stomach animal. Feed is taken into the mouth, swallowed, and then passes through the esophagus into the crop. The feed is stored in the crop where it is moistened. From the crop the feed passes into the proventriculus where digestive juices are secreted and mixed with the feed; and it then passes into the gizzard. In the gizzard the feed is ground, crushed, and then passes into the small intestine where the digested portion is absorbed into the bloodstream. The undigested portion of feed and other waste are excreted from the body. Poultry must be fed the necessary elements and all vitamins with the exception of vitamin C.

DIGESTIVE SYSTEM OF THE SWINE



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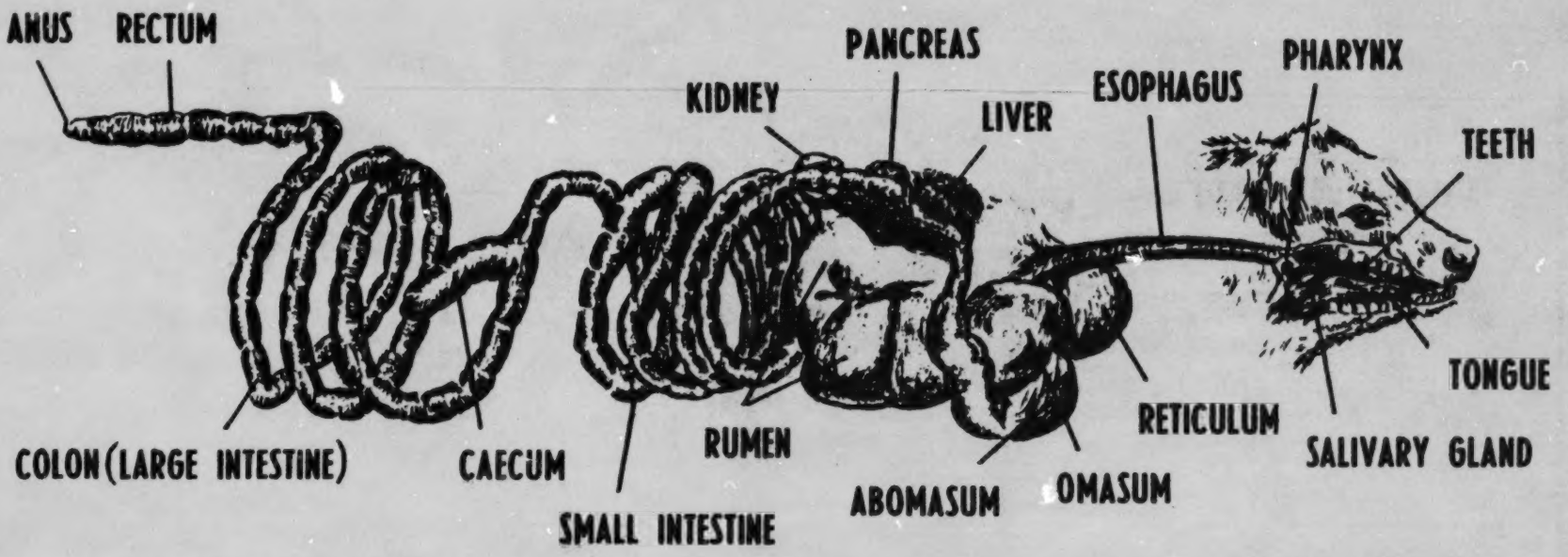
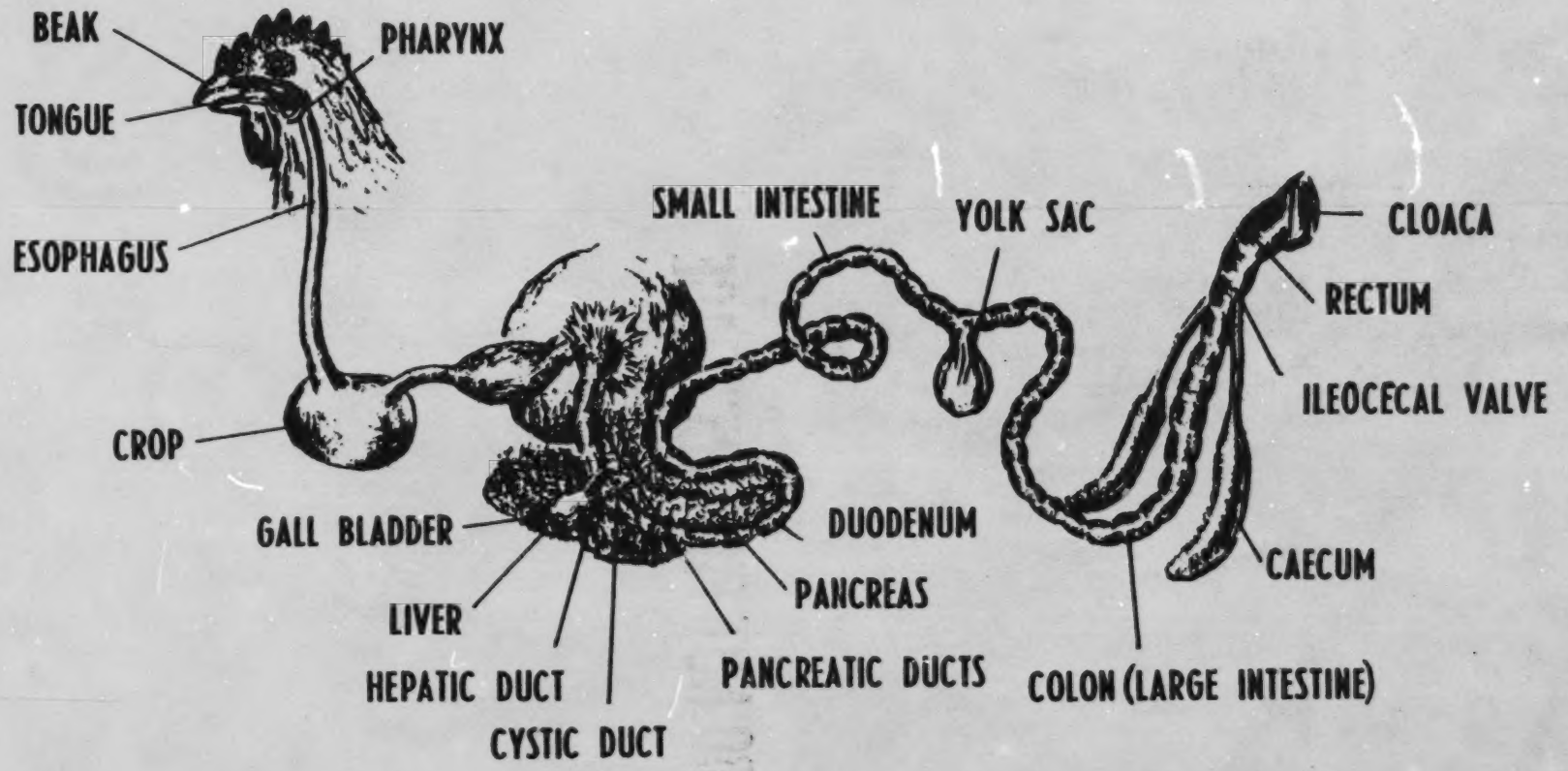
DIGESTIVE SYSTEM OF THE COW



DIGESTIVE SYSTEM OF THE CHICKEN



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Topic 2: Feed Nutrients

* Terms: All terms underlined are in the "Glossary of Terms."

1. Nutrients

Humans have long been aware of the importance of the proper kinds of food for survival, for themselves as well as their animals. Since good nutrition is a fundamental factor in the production of livestock and a knowledge of it is necessary for efficient livestock production, the producer must have a knowledge of the nutrients required for growth and reproduction.

Nutrients are classed as essential and nonessential and may be any food or group of foods that support animal life and make it possible for animals to reproduce efficiently. Nutrients are carried to the different parts of the animal's body by the blood. They pass through the walls of the capillaries and enter the cells. After entering the cells, nutrients provide nourishment and energy for the various life processes. Some of the nutrients in the cells are oxidized to provide heat for maintaining body temperature, while others furnish energy for the various movements of the body. When an excessive amount of nutrients are provided for animals, one of the following uses is made of this excess:

1. New body tissues are made, as is the case in growing and fattening animals;
2. Excessive nutrients are used in the development of the fetus in pregnant females, and poultry use excess nutrients in forming eggs;
3. Some animals transform excessive nutrients into milk; and
4. Excessive nutrients are used to produce muscular work, as is the case in working horses.

Essential nutrients are nutrients that cannot by synthesized by the body; therefore, they must be supplied in the animal's ration. Nonessential nutrients can be synthesized by the animal and are used for growth and maintenance. A nutrient may be essential for one class of animals and nonessential for another class. Nutritional requirements vary among farm animals and are affected by the stresses of work, reproduction, lactation, and rapid growth.

2. Nutritional Elements for Livestock and Poultry

Transparency No. 1

Attention is called to the variation in the percent of protein, fat, mineral matter, and water of animals of different ages. As the animal increases in weight, its nutritional requirements change. A knowledge of the body composition of animals at different ages should assist in determining the kinds of feed needed by different animals.

There are five classes of nutrients, in addition to water which is considered a nutrient in some cases. An explanation of each class

is given below:

a. Protein is formed from amino acids which are composed of hydrogen, carbon, nitrogen, oxygen, sulfur, and a small amount of phosphorus. During digestion proteins are broken down into amino acids (23 kinds of amino acids have been identified) which are carried to all parts of the body in the blood. The protein requirements are actually requirements for amino acids. Single-stomached animals are able to synthesize all but 10 or 11 of the amino acids, while ruminants can synthesize all of the amino acids needed in their diet. Ruminants also are capable of modifying some amino acids from non-amino acid sources. Since single-stomached animals cannot store amino acids, they must be supplied daily with protein. The amount of protein required by all animals varies and is determined by the class of the animals' stage of development.

   Muscles, internal organs, cartilage, connective tissue, skin, hair, wool, feathers, hooves, and horns contain a high percent of protein. Protein also plays an important role in the proper functioning of the nervous system of animals and is necessary for the replacement of the daily breakdown of body tissues, as well as providing for normal growth and development.

   Adequate protein should be provided in rations of young animals, pregnant animals, and lactating pregnant animals, since it is necessary for the proper development of the body structure. Young animals receiving a ration deficient in protein may become stunted or a runt.

   Proteins are of two kinds, plant protein and animal protein. Most plant proteins (soybean meal, cottonseed meal, linseed meal) are produced in the reproductive parts of the plant. Many of the animal proteins such as tankage, meat scraps, fish meal, and dried milk products are by-products of meat packing and other processing plants.

   Proteins are usually referred to as crude protein or digestible protein (true protein). Since all of the protein in a feed is usually not digested by animals, crude protein is the total amount of protein (digestible and non-digestible) contained in a feed. Digestible protein is the percent of protein that is digested by the animal. The type of animal and source of protein will determine the amount that is digestible. Generally, an animal will digest approximately 80 percent of the crude protein contained in a feed.

   Carbohydrates account for approximately 75 percent of a ration and are feeds that contain carbon, hydrogen, and oxygen. Carbohydrates and fats furnish the energy requirements which are necessary for animals to carry on their various body functions.

   After its energy requirements are met, the animal uses the excess carbohydrates to put on fat.

The value of high carbohydrate feeds depends upon the amount of the feed that can be digested and the amount of net energy it furnishes. Grains are high in carbohydrates and a large amount of the carbohydrates are digested. These are the reasons grains are higher in price than roughages, even though roughages are about 75 percent carbohydrates. This explains the reason why grains are higher in price than roughages, even though roughages (hay, silage, other forages) are about 75 percent carbohydrates.

Carbohydrates are divided into two groups, nitrogen-free extract and crude fiber.

Nitrogen-free extract is the more soluble and easily digested sugars and starches, which are found in corn, sorghum, wheat, barley, rye, and oats. Starch is about 1/2 to 3/4 of the solid matter found in small grains.

Crude fiber refers to the indigestible carbohydrates and is associated with plants that are high in fiber (roughages).

Ruminants are capable of digesting more crude fiber than are single-stomached animals. After being digested, crude fiber will produce as much energy as nitrogen-free extract.

In addition to providing carbohydrates, fibrous feeds aid the animal in the following ways:

1. Aid in rumination and regurgitation.
2. Aid in preventing bloat.
3. Increase the bacterial population.
4. Increase water holding capacity.
5. Provide bulk.

Fats and Oils in livestock are about the same, the difference being that fats are solids at ordinary temperature; and oils are liquid at the same temperature. Most livestock feeds contain a very small amount of fat. However, fats furnish 2 1/4 times as much energy as carbohydrates; therefore, they are important nutrients in livestock rations. Since animals require a small amount of fat, the producer usually does not consider the fat content of feeds when computing rations.

Minerals, even though they make up a very small percent (3 to 5 percent) of the body composition of animals, they are essential for proper body functions. A few of the functions of minerals are as follows:

1. The skeleton, soft tissues, and body fluids are composed chiefly of minerals;
2. Phosphorus is a vital ingredient of the chief protein in the body cells;
3. Phospholipids, phosphorus fat-like substances, are essential parts of all living protoplasm;
4. The power of the blood to carry oxygen is due to hemoglobin, the iron-protein compound in the red blood corpuscles.

5. Osmotic pressure, needed for the transfer of nutrients and waste products through the cell walls, is dependent upon minerals to function properly; and
6. The heart and kidneys are dependent upon an adequate supply of minerals to function properly.

Salt, sodium and chlorine, should be available to animals at all times. It is necessary for the animal's body to make bile, which aids in the digestion of fats and carbohydrates, and for the formation of gastric juices, which are necessary for the digestion of protein.

Transparency No. 2

Vitamins are essential for growth, maintenance, reproduction, and lactation. The word vitamin was first used in 1913 to describe certain necessary food factors present in some food material which prevented nutritional deficiencies. Vitamins are different from minerals in that they do not build body tissues. They aid in the building process but do not become part of the structure.

Vitamins are classified on the basis of their solubility, such as fat soluble and water soluble. The fat soluble can be stored and accumulated in the liver and other parts of the body; whereas, only limited amounts of water soluble vitamins are stored in the body. For this reason, it is important that water soluble vitamins be consumed regularly by the animals and in adequate amounts.

Transparency No. 3

Water - An abundance of water is needed by all animals in order for their bodies to function properly. Water is necessary for digestion, absorption of food nutrients, removal of body waste, and the regulation of body temperature. Fifty percent of animals' bodies is water, and some body tissues contain over 90 percent water.

Animals require approximately 3 pounds of water (1 gallon weighs 8.43 lbs.) for each pound of solid food consumed; however, weather and temperature will affect their consumption. It is important and essential that fresh water be provided for all animals.

Since water and the area around watering facilities are usually an ideal place for the spread of disease, the producer should provide sanitary watering facilities with ample space for all animals.

COMPOSITION OF ANIMALS' BODIES

	Protein	Fat	Mineral Matter	Water
Dairy calf	19.4	7.2	4.3	69.1
Dairy heifer, 1 yr.	19.2	12.7	4.4	63.7
Beef steer, 700 lbs.	18.6	16.6	4.5	60.3
Fat steer, 1200 lbs	16.0	32.3	3.7	48.0
Horse	18.2	14.1	4.7	61.9
Sheep	15.7	19.9	3.4	61.0
Pig, 200 lbs.	14.5	28.5	2.7	54.0
Pullet, 4 lbs.	19.2	20.0	5.0	55.8

FAT AND WATER SOLUBLE VITAMINS

FAT SOLUBLE VITAMINS	WATER SOLUBLE VITAMINS
Vitamin A	Vitamin B complex
Vitamin D	Thiamin or Vitamin B1
	Riboflavin or Vitamin B2
Vitamin E	Pyridoxine or Vitamin B6
	Niacin or Nicotinic Acid
Vitamin K	Pantothenic Acid or Panacid
	Choline
	Folic Acid
	Vitamin B 12
	Para - aminobenzoic acid or PABA
	Inositol
	Ascorbic Acid or Vitamin C
	Biotin

A DAILY WATER CONSUMPTION GUIDE FOR ANIMALS

SWINE	2 - 3 gallons per head per day depending on age and size
SHEEP	1 - 2 gallons per head per day
CATTLE (adults)	8 gallons per head per day
HORSES	8 gallons per head per day
HENS	5 gallons per 100 birds per day
CHICKS	vary with age
TURKEYS	7 - 8 gallons per 100 birds per day
TURKEY POULTS	vary with age

Topic 3: Classes of Feed

*Terms: All terms underlined are included in the "Glossary of Terms."

I. Feed classification

Nutritionists classify feeds several different ways. One of the methods used is based on the fiber and total digestible nutrients (TDN) contents of the feed. Using these two factors as a basis, feeds are classified as concentrates and roughages.

Concentrates are feeds that are high in total digestible nutrients and/or protein and low in fiber. Total digestible nutrients include the digestible organic nutrients (protein, fiber, nitrogen-free extract, and fat), or that part of the organic nutrients that the animal is capable of digesting. The amount of total digestible nutrients in a feed may be determined by adding the sum total of the protein, fiber, nitrogen-free extract, and fat. Since fat provides 2.25 as much energy value as that of protein or carbohydrates, it is multiplied by 2.25 to determine its feeding value.

Roughages are feeds that are high in fiber and low in total digestible nutrients.

II. Concentrate Feeds

Concentrates include a number of different feeds and contain a high percent of easily digested carbohydrates. Some concentrates are more readily available in Oregon than others, and the prospective livestock producer should become acquainted with the feeding value of the concentrates that are available. Producers, having a knowledge of feeds, are often able to substitute one feed for another and obtain the same results with less expense. They may substitute one concentrate for another, one roughage for another, or roughage for a part of the concentrate in the ration.

Using similarities in composition and feeding values as a basis, concentrates may be classified as grains, processing by-products, animal proteins, plant proteins, and liquid supplements.

Transparency No. 1

Space limitations prohibit the discussin of all of the feeds under each of the above classifications; therefore, only the feeds that are usually available to the livestock producers in Oregon are included in this topic.

Grain

a. Corn - This is the most extensively grown and fed grain in the United States. The Economic Research Service estimated that 150 million tons of corn were used annually as a feed grain. This is more than six times the amount of grain sorghum, the second most extensively fed grain during the same period. Corn is high in energy and TDN, but contains insufficient amounts of calcium, riboflavin, and pantothenic acid.
b. Oats - They contain more crude fiber and are lower in TDN than corn. About 10 percent as much oats as corn are fed to livestock. Oats are an excellent feed for horses and growing livestock, but they are not recommended as the only

source of grain in fattening rations. The amount of hulls on oats determines their feeding value. The variety and weather conditions affect the amount of hull. Oats are usually crimped, ground, or rolled when they are included in a ration.

c. Barley - Barley is often substituted for oats in rations for horses, show animals, and breeding stock. Barley is considered to be a better grain than oats, since it contains more protein, more TDN, and less fiber. Barley should be coarsely ground, rolled, or crimped.

d. Wheat - Very little wheat is consumed by livestock because it is in great demand for human consumption. Wheat is comparable to corn in feeding value and can be substituted for corn when it can be purchased as economically. The best result; however, is obtained when only a part of the grain ration is wheat. This is especially true when it is fed to cattle and horses. Wheat should be coarsely ground or cracked. A potential hazard of feeding large quantities of wheat is a pastiness in the large intestine.

e. Ground ear corn - Depending on the quality of the grain, ground ear corn contains from 70 to 80 percent grain and 20 to 30 percent cob. It is higher in fiber and lower in TDN than shelled corn. Because of its high fiber content, ground ear corn should not be fed to nonruminants; but it is recommended for the feeding of fattening cattle and horses. The amount of other roughages should be reduced when fed to these animals.

Processing By-Products

a. Wheat bran - Bran is produced in the manufacturing of wheat into flour. It is an excellent source of bulk and is a mild laxative. The recommended feeding level in the rations is beef and cattle, dairy cattle, brood sows, and horses is 10 percent of the ration. It is not recommended for the feeding of pigs and fattening and/or growing cattle.

b. Wheat middling and shorts - The different processes used in manufacturing wheat flour will depend upon the composition and kind of middling or shorts one is able to purchase. Various portions of bran, germ, and coarse flour make up the contents of these feeds; and there is considerable variation in the fiber and TDN content. These can be used effectively as a part of the swine ration; however, they do not contain all of the essential amino acids. They are not recommended for other classes of livestock.

c. Rice bran - Rice bran contains the seed coat and germ of the rice grain and is a by-product of the manufacture of polished rice. It is comparable to wheat bran in feeding value but contains less protein. It is used principally in the rations of dairy cattle. Because of the high fat and fiber content and poor palability of rice bran, not more than 30 percent of a ration should be rice bran.

d. Animal fat, feed grade - This is a by-product of slaughtering and processing plants and may be used to a limited extent in rations as a source of energy. The kind of animal receiving the ration will determine the level of fat in the ration. A maximum of five percent may be used in beef cattle rations, while swine can effectively utilize fat at the 10 percent level. Fat should be treated with an anti-oxidant to prevent rancidity.

Liquid Supplements

The feeding of a blackstrap molasses-urea liquid supplement to cattle receiving low protein forage has increased in popularity among livestock producers. The major advantage offered for the liquid supplements is a saving of labor, as the same results may be obtained by feeding a range mixture consisting of a high protein feed and mineral. The principal ingredient in the mineral is salt, which limits the amount of feed consumed.

The protein content of the blackstrap molasses-urea supplement is 30-35 percent. The liquid is placed in a tank, and the animal consumes the supplement by licking a partially submerged float, or a wheel that turns the liquid. Beet and citrus molasses may be substituted for the blackstrap molasses.

Plant Proteins

a. Soybean meal - This is the most widely used of the plant protein feeds and represents about 65 percent of the high protein feeds fed. Most soybean meal is produced by the solvent-extract method and contains from 44 to 49 percent protein. The percent of protein in the meal is dependent upon whether the whole soybean or the soybean with the seed coat removed was used to produce the meal. It is an excellent source of protein for poultry and swine and can be used in cattle rations.

b. Cottonseed meal - This is the principal source of protein in the southern states where cotton is grown. It contains either 41 or 36 percent protein, which is determined by the amount of cottonseed hulls left in the meal. Thirty-six percent protein is the minimum percent of protein for ruminants, but no more than 10 percent meal should be used in swine rations. There is a possibility that a greater amount in the swine ration will produce a toxicity caused by the phenolic pigment found in cottonseed.

c. Linseed meal - It is a by-product produced by the extracting of fat from flax seed. It contains 35 percent protein and is a good protein source for most classes of livestock. The feeding of linseed meal will put a bloom on animals. For this reason, it is recommended as a protein source for all classes of livestock.

d. Peanut oil meal - This meal is produced by grinding the peanut kernels into a meal after the fat has been extracted. The amount of peanut hulls and the method of fat extraction will determine the protein content. The usual protein content is about 35 percent. Peanut oil meal is comparable to soybean oil in feeding value and may be used as a protein source for all classes of livestock.

Animal Proteins

a. Meat scraps - The feeding of this source of protein is increasing. It is produced by cooking animal tissue and bone in their own fat in a steam jacketed kettle. The cooked material is then ground. Meat scraps are more desirable than tankage because dried blood is not included. The protein content is 55 to 60 percent and is affected by the amount of bone included. Meat scraps are used as a source of protein in the rations of poultry and swine.

b. Tankage - This is commonly referred to as digester tankage and contains animal tissue and bone which are cooked under steam pressure and ground. It is comparable in feeding value to meat scraps and may be higher in calcium and phosphorus. However, this will depend upon the bone content of the tankage.

c. Fish meal - This is produced by drying and grinding fish and fish by-products. The protein content is around 60 percent and is used mostly in swine and poultry rations.

d. Blood meal - Being produced by grinding dried blood, blood meal contains about 80 percent protein. The protein is of lower quality and not as digestible as other sources of animal protein. It is also lacking in palatability.

III. Roughages

Roughages are high in fiber and furnish an inexpensive source of carbohydrates for ruminants. Since single-stomached animals can digest only a small amount of fiber, the feeder should limit the amount of roughage fed to these animals. Roughages are classified as dry roughages, green roughages, and silage. A discussion of some of the more commonly used roughages in each category is given.

Transparency No. 2

Dry Roughages

Included in this category are hays (grasses and legumes), straw (Oat, barley, wheat, and rice), and fodder (corn and sorghum).

a. Grasses and legumes - Alfalfa hay is the most nutricious and higher in protein than all the other dry roughages. It is palatable, succulent, and relished by ruminants and many single-stomached animals. Many kinds of grass hay are utilized as dry roughage for animals, the feed value of grass hays vary tremendously and are dependent on stage of maturity when cut and weather conditions during the cutting time.

b. Straw - The different kinds of straws are low in nutritive value and should be supplemented with protein, minerals, and vitamins. Most of the straws are used as bedding for show animals maintained in barns for long periods of time.

c. Fodder - Corn and sorghum fodder are the two most common. They provide very little nutritive value and should be supplemented with protein, minerals, and vitamins.

Green Roughages

Grasses, legumes, tubers (potatoes), and fodder (corn and sorghum) are sometimes fed as green roughages. The feeding of green roughage usually requires the producer to use special equipment to harvest and haul to the livestock. However, it can be used to replace pasture.

The harvesting and storing of high moisture grain and forage crops in glass lined steel tanks by dairymen and feedlot operators has increased in the last few years. These crops are called haylage. The system used to store these crops allows a limited amount of oxygen to enter the tank, and there is little loss due to storage. The feeding value of these feeds would depend upon the type of crop stored and the quality and maturity of the crop when prepared for storage. Haylage is generally superior to dry roughage. These feeds make up only a part of the ration and should be supplemented with protein and mineral.

Silage

Silage is made from green grasses and grain crops that are cut and stored in siloes. Corn and sorghum silages yield more TDN than most other crops used for silage. While in storage silage goes through a fermentation process which makes it highly palatable. Other advantages of feeding silage are as follows:

1. Grasses and legumes fed as silage have more feeding value than when fed as dry roughages;
2. If the crop being used for silage is cut in the proper stage of maturity, the silage will be of higher quality and more succulent;
3. Silage may be stored in almost any kind of weather;
4. There is less waste because the animals will eat all of the plants used for silage; and
5. Weedy crops which would produce poor quality hay can produce quality silage.

Silage should be supplemented with protein, mineral, and possibly other feeds.

CLASSIFICATION OF CONCENTRATES

Grains

BARLEY
CORN
GRAIN SORGHUM
OATS
WHEAT
GROUND EAR CORN

Processing by-products

WHEAT BRAN
WHEAT MIDDLINGS AND SHORTS
RICE BRAN
ANIMAL FAT, FEED GRADE

Liquid supplements

BLACK STRAP MOLASSES
UREA
BEET MOLASSES
CITRUS MOLASSES

Plant proteins

SOYBEAN MEAL
COTTONSEED MEAL
LINSEED MEAL
PEANUT MEAL

Animal proteins

MEAT SCRAPS
TANKAGE
FISH MEAL
BLOOD MEAL

CLASSIFICATION OF ROUGHAGES

DRY ROUGHAGES

Hays--Grass and Legume

Hulls--Peanut and Cottonseed

Straw--Oat, Wheat, Barley, and Rice

Fodder--Corn and Sorghum

GREEN ROUGHAGES

Roots

Grasses

Legumes

Tubers

Fodder

SILAGE

Corn

Sorghum

Grass

Topic 4: Digestion and Absorption

*Terms: All terms underlined are included in the "Glossary of Terms".

1. Introduction to Digestion and Absorption

Digestion is a term used to refer to the changes that take place in feed as it travels through an animal's digestive tract in preparation for absorption and use by the animal's body. The digestive system performs five major functions: food intake, storage, digestion, absorption, and elimination of waste. During the digestion processes, food is broken down into simple chemical compounds by enzyme action. Enzymes, organic chemical compounds, produce change in the food eaten by animals without being changed themselves. Some enzymes are capable of digesting 4,000,000 times their own weight of feed. The names given to the different enzymes is based upon the action they promote, or the compounds on which they act. For example, sucrase acts only upon sucrose. Pepsin and trypsin act on proteins and are called proteinases.

Absorption is the entering of a substance into the blood stream; it may occur from the surface of the body into the body, from the body cavity, or from one of the body organs. However, most absorption of food takes place in the small intestine, which is covered with millions of small, finger-like projections called villi. The villi increase the surface of the small intestine many times and aid in absorbing food.

All of the feed eaten by animals is not used for growth, body maintenance, and production. Only the feed that passes through the walls of the digestive tract is used by the body and is digested. It is important that the livestock producer understand that certain feeds are more digestible and that certain animals can digest a higher percentage of certain feeds. Composition of feed, feed intake, and differences among animals affect digestibility.

2. Types of Digestive Systems

The chemical process in the digestion of food by most animals are similar. Food substances are broken down into small particles, and moisture is added during the digestive processes. There are considerable differences; however, in the anatomical features of the digestive tracts of different species.

Transparency No. 1

Cattle, sheep, and goats (ruminants) have four compartments to their stomachs and can utilize large amounts of feed, both concentrates and roughages. All four compartments of a grown cows stomach can hold as much as 250 quarts of feed.

Cattle pull in large amounts of feed with their strong tongues, eat rapidly, seldom pause, and chew only a small amount of feed while they are eating. The feed goes into the rumen and reticulum wher it is stored for many hours. While the feed is in the rumen and reticulum, bacteria begin the digestion process.

As the bacterial action is taking place, the coarse feed eaten by the cow is regurgitated into the cow's mouth for rechewing. The rechewing of this feed is known as the cow "chewing her cud."

Feed taken into the ruminant's stomach follows one of three routes as it is digested. Concentrate feeds (route No. 1) usually go from the esophagus to the reticulum into the omasum. From the omasum, the feed goes to the abomasum, the small intestine, the large intestine, and is then eliminated as waste. Another route (No. 2) that feed may take through the ruminants' stomach is to be flushed into the back of the rumen, enter the reticulum from the rumen and pass on to the omasum, into the abomasum, and into the small intestine.

By the third route, the feed completes the circuit of the rumen. After entering the reticulum, the feed is regurgitated, rechewed, and swallowed again. The feed may then follow route one or two. It takes approximately four days after the feed is eaten for it to pass through cattle.

Liquids are constantly being circulated between the rumen and the reticulum. This aids digestion by keeping the feed in these compartments moist.

Both mechanical and chemical factors are important in digestion. The enzyme action previously mentioned is an example of chemical action. Mechanical factors which aid in digestion are chewing, swallowing, and pumping action within the reticulum, and other muscular action within the digestive system. At the beginning of rumination the reticulum contracts. This forces the food in the reticulum upward and backward and into the rumen. When the reticulum relaxes, it fills with feed that has been fermenting in the rumen. This process, called rumination continues for about 45 minutes. The food is regurgitated, rechewed, saliva is added, and the feed is reswallowed.

Cattle have six to eight rumination periods each day. From five to seven hours are spent in rumination, and 90 to 130 pounds of feed are regurgitated and rechewed daily.

Feeds such as grass and hay must be ruminated; otherwise, it cannot be digested. Since grains normally pass directly to the abomasum, they do not usually appear in the cud.

After the feed is rechewed by cattle, it goes into the reticulum. The most of it goes to the omasum. The omasum contracts, water is squeezed out, and the feed is forced into the abomasum. Other muscular action in the digestive tract forces feed along the tract.

The amount of feed left in the digestive tract affects the appetite of cattle. Cattle fed easily digested feeds, such as corn, have better appetites than cattle fed harder to digest feeds such as hay.

Normally about four days are required for feed to pass through the digestive tract of ruminants. The usual amount of time

feed is in each compartment of the stomach is listed below:

Rumen and reticulum	- 61 hours
Omasum	- 8 hours
Abomasum	- 3 hours
Small intestine	- 7 hours
Large intestine	- 8 hours

Transparency No. 2

Swine and horses have simple stomachs. The digestive system of swine is being used as an example in the transparency.

The stomach of a grown swine has a capacity of about 8.5 quarts of feed. Since they do not have a large storage capacity for feed, swine must chew their feed before it is swallowed. Another reason pigs chew their feed much slower than ruminants is to mix the feed with the enzymes in the mouth. The feed eaten by swine goes from the mouth to the esophagus, and into the stomach. From the stomach, it passes through the small and large intestines. Feed passes through a pig's digestive tract in approximately 24 hours.

Even though their digestive system is similar to that of swine, the horse's cecum and colon are greatly enlarged; and this enables its large intestine to hold from 120 to 140 quarts of feed. This capacity allows the horse to consume and digest a large amount of roughage.

Transparency No. 3

Chickens use their tongues to force feed into the gullet (esophageal canal) and into a pouch called the crop (invulvies). While the feed is stored in the crop, salivary action takes place; and the feed is softened and undergoes predigestion. As the feed travels to the gizzard, stomach gastric juices containing pepsin surround the food to further aid in digestion. The gizzard, aided by grit and gravel eaten by the chicken, crushes the feed. From the gizzard, the feed travels to the small intestine digestive juices are secreted into the duodenum loop from the pancreas for digestion of carbohydrates, proteins, and fats. Alkaline bile is also secreted into this region from the gall bladder to neutralize the acids and create a favorable condition for digestive enzymes. The absorption of food takes place in the coiled portion of the small intestine. The large intestine, which serves as a storage for fecal matter, extends from the small intestine to the cloaca. Fecal material, eggs from the oviduct, and urine from the kidneys all pass through the cloaca and are eliminated by way of the vent.

3. Digestion of Carbohydrates, Proteins, and Fats

Carbohydrates, the main energy nutrients, are made up of carbon, hydrogen, and oxygen. There are thousands of combinations of these three elements. Sugars and starches are the easiest of the carbohydrates to digest and are of high feeding value. Sugars and starches are high in feeding value because small amounts of these pass through the bodies of animals.

Cellulose, also a carbohydrate, is composed of the fibrous parts of plants and is difficult for most animals other than ruminants to digest.

Carbohydrate Digestion

With the aid of bacteria and protozoa, cattle digest carbohydrates in their rumen. The carbohydrates are broken down into simple sugars, like glucose (blood sugar). The carbohydrates not digested in the rumen are digested in the true stomach, as in non-ruminants.

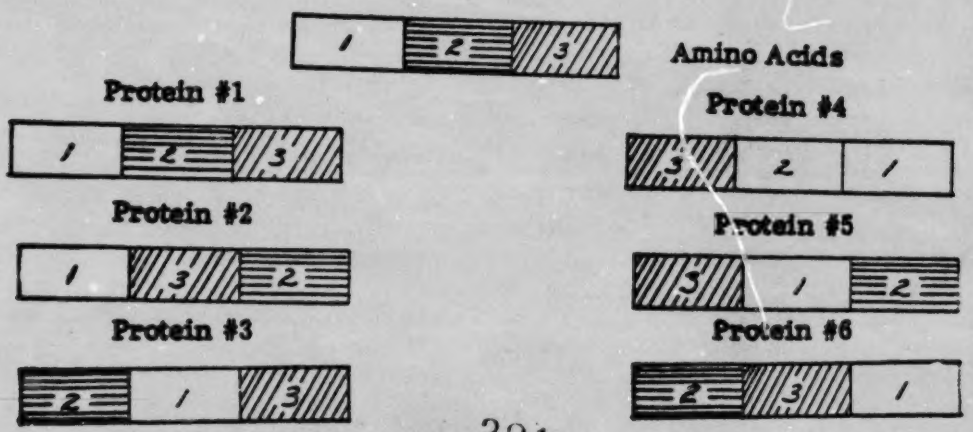
Swine begin the digestion of carbohydrates in their mouths. As they chew, saliva, containing an enzyme called salivary amylase, breaks starches down into sugars. The enzymes continue this action until the starches reach the stomach, where the action is stopped by stomach acid. After reaching the small intestine, carbohydrates that have not been completely broken down are broken down by other enzymes. The enzymes continue the process of breaking down carbohydrates into simple sugars until the digestive process is concluded.

Poultry start the digestions of carbohydrates in the gizzard. Three digestive enzymes are secreted in the pancreatic juice, and these break starches down into complex sugars. As food passes into the small intestine, sugar splitting enzymes break down the compound sugars into simple sugars (glucose), the end product of carbohydrate digestion. Sugars and starches are easily digested by poultry, but fibers are poorly digested.

Protein Digestion

Proteins also contain carbon, hydrogen, and oxygen, but in addition they contain nitrogen. Some proteins also contain sulfur, and a few contain phosphorus or iron. Nitrogen is similar to carbon in that it will combine with other chemical elements in many different proteins. Each protein is composed of several nitrogen compounds called amino acids. Amino acids are often described as being the building blocks from which proteins are made. The quality of a protein is determined by the chemical arrangement of amino acids.

Even though proteins are made up of the same amino acids, there are not any two proteins alike. The following is used to illustrate:



The digestion of protein by cattle begins in the rumen. The protein is broken down by rumen bacteria. These bacteria require amino acid in order to develop and multiply. The protein is broken down into an ammoniagas, a simple form of nitrogen. It is used by the bacteria to rebuild their bodies. As the bacteria in the rumen die and pass into the small intestine, the protein contained in their bodies is used by the ruminant. Cattle do not require a special balance of amino acids because of the bacteria in the rumen to manufacture amino acids from nitrogen.

The beginning of protein digestion in swine is in their stomachs. The enzyme pepsin begins the action on protein. This results in the formation of protein chains. These pass to the small intestine and are broken down into amino acids. The amino acids are absorbed through the walls of the small intestine. Certain amino acids must be provided in swine rations because swine are not able to manufacture them in the digestion process.

While the feed is being ground and mixed in the gizzards of poultry, proteins are broken down into proteoses and peptones. These are broken down further by trypsin while the carbohydrates and fats are being digested in the duodenal loop. The secretion of erepsin in the small intestine splits the protein into amino acids and completes the digestion of protein.

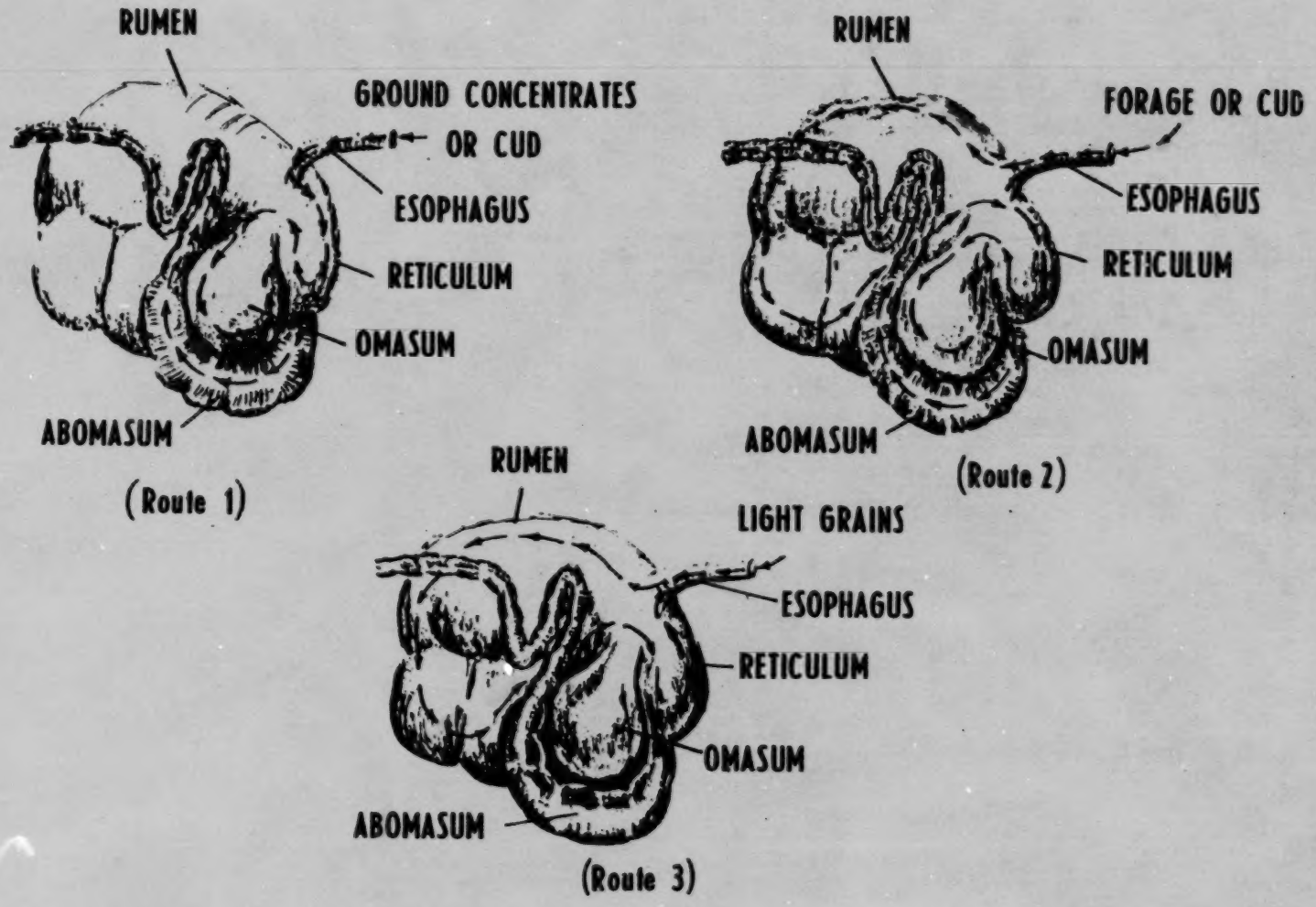
Fats

Fats are digested by cattle in the abomasum and small intestine. Pigs digest fats in the stomach and small intestine. Fats then change to fatty acids and glycerol for digestion and absorption.

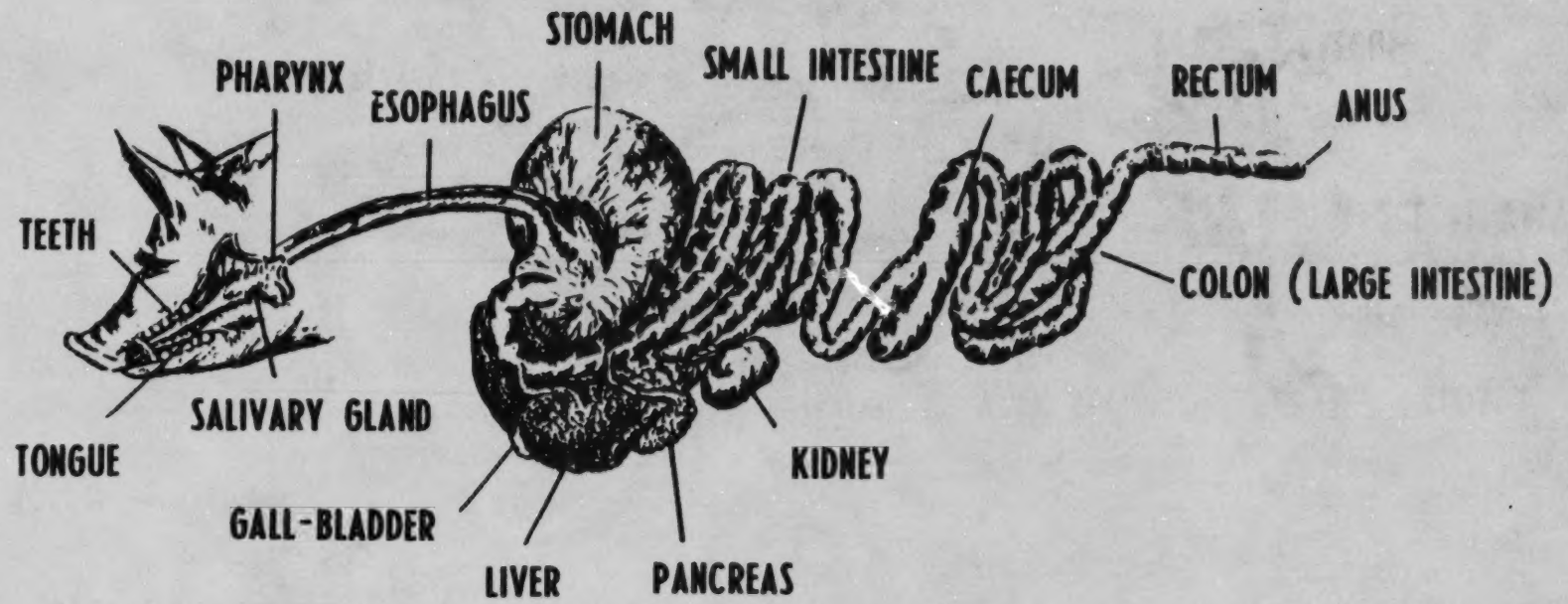
Fats are difficult for poultry to digest. The fat is emulsified in the duodenal loop by the bile salts of the liver. Then they are broken down into fatty acids and glycerol for digestion.

Metabolism, a term often used in explaining digestion, is the further breaking down of food products to meet the specific needs of cells. Some are used to replace worn-out cells. Others are used for energy or stored for later use.

THREE ROUTES OF FEED-STUFF IN RUMINANTS



DIGESTIVE SYSTEM OF THE SWINE



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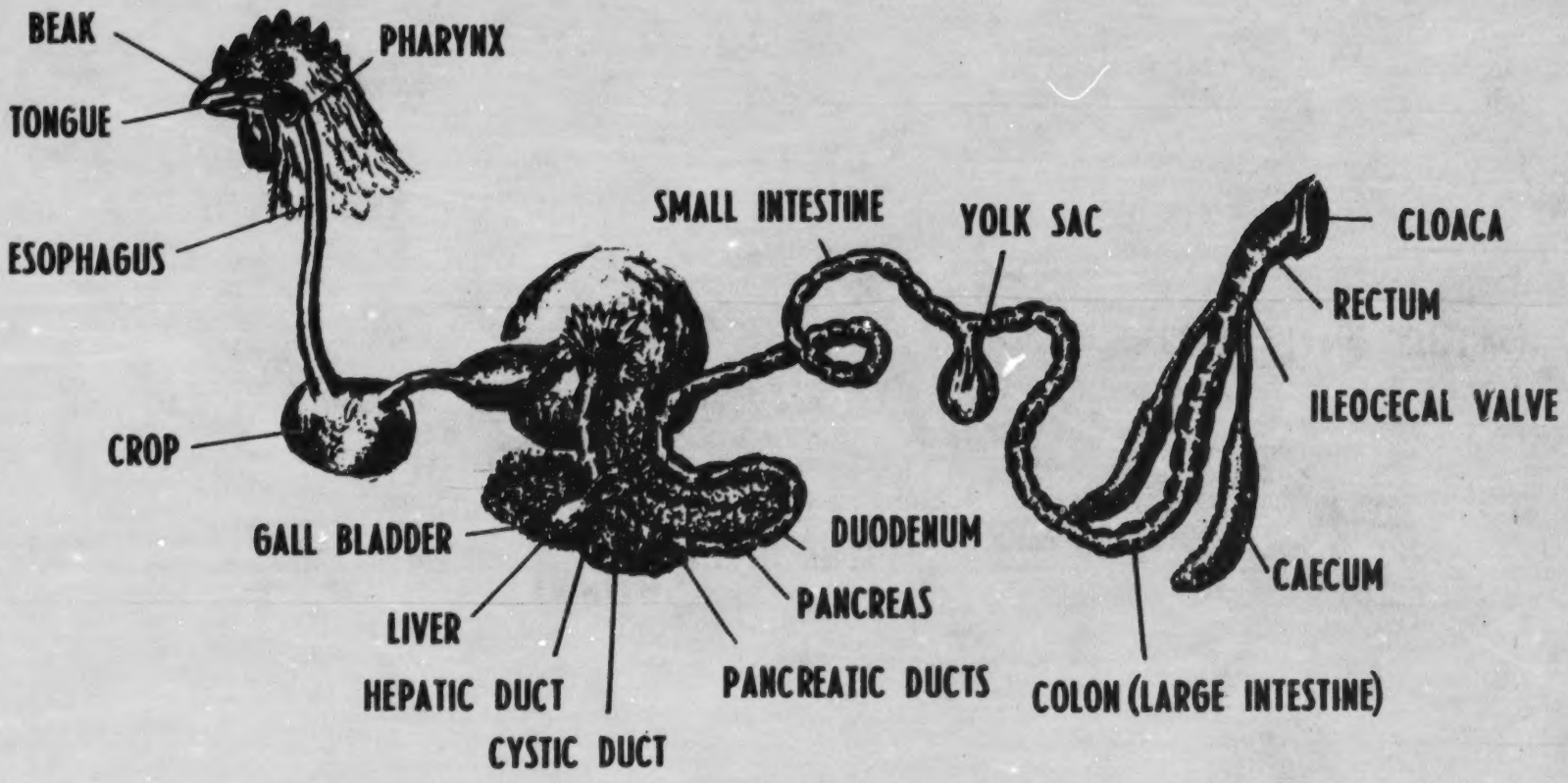
DIGESTIVE SYSTEM OF THE CHICKEN



Topic 6: Rations

*Terms: All terms underlined are in the "Glossary of Terms".

1. Rations for Livestock

Feeds vary in their nutritive value, and the digestion of feed varies among the different classes of animals, as well as varying among animals within the same class. However, livestock producers today have a much better guide for estimating an animal's nutritive requirements than was once available. Feeding standards and feed digestion tables, based on research, have been prepared and are available for determining animals' daily nutritive requirements.

The words ration and balanced ration are used as synonymous terms, but they have different meanings. A ration is the feed received by an animal for a 24-hour period. A balanced ration is a mixture of feeds that meet the animal's nutritive requirements and is fed to an animal in a 24-hour period.

Before beginning to compute rations, one must know the nutritive requirements for different classes of animals. These include requirements for maintenance, growth, fattening, and reproduction.

2. Maintenance Rations

Some rations are formulated to maintain the animal at its present weight and size. These rations are usually high in carbohydrates and fats and contain small amounts of protein, mineral, and vitamins. Animals receiving these rations may be idle work animals, non-producing breeding animals, or animals retained at their present weight for other specific purposes.

Growing Animals

Growing animals, which include young animals and animals being developed for breeding stock, should be fed feeds relatively high in protein, mineral, and vitamins.

Fattening Animals

Fattening animals should be fed large amounts of carbohydrates and fats and an ample supply of protein. Fattening animals (cattle, swine, and sheep) are usually confined in a feed lot.

Producing Animals

Animals in production, such as lactating dairy cattle, must be fed a ration that meets the requirements for body maintenance and production. Since milk is high in protein, calcium, and phosphorus, producing animals should be fed feeds that contain liberal amounts of these. Eggs are rich in protein, fat, and minerals, and vitamins; therefore, laying hens also must be fed feeds high in these nutrients.

Reproducing Animals

Reproducing animals or animals in their gestation period must receive an adequate level of nutrients; otherwise, fertility will be lowered, or temporary sterility may develop. Deficient

rations will cause irregular reproduction, a lower percentage of calf and lamb crops, small and weak litters of pigs, and poor hatchability in poultry. A liberal supply of protein, mineral, and vitamins should be provided for reproducing animals.

3. Essentials of a Good Ration

Transparency No. 1

It is possible for a ration to have the following essentials without being a good ration, but a good ration will generally include these essential elements:

(1) The ration should be balanced. Faster gains, less expensive, and more profits are realized from feeding balanced rations.
(2) The ration should contain a variety. A variety of feeds will generally increase the palatability of the ration and make it easier to balance the nutrients.
(3) The ration should be succulent (juicy, fresh, and rich). A succulent ration will increase production.
(4) The ration should be palatable, agreeable to the taste. If the ration is not readily consumed, the producer will not receive the maximum production.
(5) The ration should be bulky. A ration containing some bulk (ground oats, wheat bran, beet pulp, etc.) is usually more desirable.
(6) The ration should be slightly laxative. A laxative ration is more efficient.
(7) The ration should be economical. The ration should be economical while providing the essential nutrients.
(8) The ration should be suitable to the type of animal. The digestive systems of animals differ. Cattle and sheep can consume large amounts of roughage, while poultry and swine rations must consist largely of concentrates.

There are certain "rules of thumb" which may assist a producer in selecting the kinds and amounts of feed to use in rations. Some of these rules are as follows:

Beef Cattle

Beef cattle can be fed approximately 2 pounds of air-dried roughage for each 100 pounds of body weight. If silage is substituted for dry roughage, it usually is substituted at the rate of 3 pounds of silage for each pound of dry roughage.

Concentrates may be fed to fattening beef cattle at the rate of 2 pounds for each 100 pounds of body weight; fattening cattle rations normally contain less than 2 pounds of roughage per 100 pounds of body weight.

Lactating Dairy Cattle

Dairy cattle may be fed 2½ pounds of roughage for each 100 pounds of body weight, if the roughage is of good quality.

The quality of concentrates to feed should be determined by the cow's production and the quality of roughage fed. The percentage of protein in the ration will be determined by the quality and kind of roughage fed.

One pound of concentrates is recommended for each 3 pounds of milk given by Jerseys and Guernseys; and 1 pound of concentrates for each 4 pounds of milk produced by Holsteins, Brown Swiss, and Ayshires is recommended.

Sheep

It is recommended that sheep receiving maintenance rations be fed 3 pounds of roughage, supplemented with protein and mineral, for each 100 pounds of body weight.

Swine

The rations for bred sows and gilts, being fed on selffeeders, may contain from 12 to 15 percent roughage. If bred sows gain too much weight, the roughage may be increased; and if the bred animal needs to gain weight, the roughage in the ration should be decreased and the concentrates increased.

Transparency No. 2

The rations for growing and fattening pigs should provide protein, mineral, vitamins, and antibiotics. While 35 or more amino acids have been found in proteins only ten are considered essential for swine; and the essential amino acids must be provided in the swine ration if the pigs are to grow properly. The number of essential amino acids needed by swine is based on available research. Future research may determine that others are needed.

Energy may be provided by feeding grains; and a mixture of animal and plant proteins will provide the needed proteins.

Limestone, steamed bone meal, and a mineralized salt fed in a 2:2:1 ratio will usually meet the mineral requirements of pigs. The ration may contain as much as 2.5 percent mineral.

The producer should feed an adequate amount of vitamins, and should follow the manufacturer's recommendation as to the amount of antibiotics to feed.

Fattening pigs will consume from 3.5 to 5.0 pounds of concentrates per 100 pounds of body weight. Older sows nursing litters should be fed 2.0 to 2.5 pounds of concentrates for each 100 pounds of body weight.

Transparency No. 3

Poultry

The nutritional requirements for poultry are essentially the same as those of other farm animals; however, one should remember that poultry are unable to digest large amounts of roughage. Laying hens require a ration that will meet the requirements for body maintenance as well as for production.

Nutritionists have not developed a feeding standard for poultry which gives the exact requirements of digestible nutrients, as has been done for other farm animals; however, the National Research Council has developed recommendations for nutritive requirements needed per pound of poultry ration.

Horses

The amount of grain and roughage fed to horses is determined by the size of the horse, the amount and kind of work it is performing, and its age. Since the horse has a small digestive tract (capacity in quarts: stomach 8-16, cecum 28-32, and large intestine 80) as compared to a cow, the rations for horses with high energy requirements must be largely concentrates. Although there has been very little research conducted on the nutritional requirements of horses and digestion of feeds, it is suspected that the amount of bacterial synthesis and the efficiency of absorption of nutrients synthesized by the micro-organisms are likely to be lower in a horse than in a ruminant. The amount of hay and grain fed daily will vary from 1/2 pound of grain and 1 1/2 pounds of roughage per 100 pounds of body weight to 1 1/3 of grain and 1 1/4 pounds of roughage.

4. Selecting and Determining Values of Feeds

There are several methods of determining the values of feeds. Three of the most commonly used methods are determining the cost per pound of total digestible nutrients, determining the cost per pound of protein, and comparing the cost of feeds listed in a tabular form. An explanation of each follows:

Transparency No. 4

Comparing the Cost Per Pound of T.D.N.

The total digestible nutrients (T.D.N.) is the sum of all digestible nutrients including protein, fiber, nitrogen-free extract, and fat.

To determine the value of feeds by comparing the cost per pound of T.D.N. the producer would first determine the amount of T.D.N. in each feed being compared.

Second, the amount of T.D.N. is divided onto the selling price of feed to determine the cost per pound of T.D.N.

Third, the cost per pound of T.D.N. is compared.

Based on the T.D.N. content and the selling price, oats are slightly cheaper than corn.

Another method of determining the value of two feeds based on T.D.N. content of the two feeds into the smaller T.D.N. content. For example: 80 (T.D.N. of corn) divided into 70 (T.D.N. of oats) =.87, which means that oats is 87 percent of the value of corn, based on their T.D.N. content.

Comparing the Cost Per Pound of Protein

The cost per pound of protein is determined in the same manner as the cost per pound of T.D.N. is determined.

Tabular Method

Several feed manufacturing firms, government agencies, and others have developed feed comparison charts in tabular form. Grain comparison charts for cattle and sheep, hogs, and dairy cattle are in transparency No. 5.

Transparency No. 5

The grains listed under corn in the Grain Comparison Charts may be substituted for corn and are of comparable value when they can be purchased for the prices shown. For example, a beef cattle feedlot operator can pay $4.34 per cwt. for milo when corn is selling for $4.64 per cwt. and receive the same feeding value. If corn is selling for more than $4.64 per cwt., milo selling fot $4.34 per cwt. would be the most economical purchase. The grains shown in the comparison chart are of equal quality.

One factor the feeder should be aware of in substituting grains is that wheat should not constitute more than 1/3 of the ration.

There are also hay comparison charts available. Secure a copy of "What to Look for in Evaluating Hay" Extension Circular 942, Oregon State University Extension Services. A chart provides information on excellent, good, fair, and poor quality hay.

Other Factors Determining Values of Feeds

There are many factors other than cost that will determine the value of concentrates; some of these are the grade of grain used, species of animal receiving the feed, age of animal receiving feed, feed preparation, moisture content of ingredients, and fertility of the soil the feed was grown on. To accurately determine the value of a feed, a producer must have a chemical analysis made of the grains or ingredients used. Use the average analysis shown in a number of publications if you are unable to get a chemical analysis made.

Determining the Value of Commercial Feeds

In addition to being able to determine the value of single concentrates and roughages, a livestock producer must be able to determine the value of commercial feed mixtures. The feed tag or label can be used to determine the value of a commercial feed. The hypothetical feed label shown in transparency No. 6 is incomplete. An actual label usually would be more detailed.

Transparency No. 6

Feed manufacturers are required to operate under the closed formula law, which means that commercial feeds shall be labeled with the information prescribed in the regulations.

The Oregon Department of Agriculture is the agency responsible for regulating the labeling of feed and fertilizer, and requires the following information on the label of a commercial feed:

a. Net weight must be shown on label or container.
b. Brand name and product name.

c. The term "Medicated" when the feed contains a drug or combination of drugs.
d. The purpose of the medication.
e. The direction for use.
f. The active drug ingredients listed by common or usual names and amounts.
g. Guaranteed analysis of the feed.
h. The feed ingredients.
i. Name and address of manufacturer or registrant.

The ingredients in a commercial livestock feed do not have to be listed in any special order; however, feeds containing ingredients with special emphasis must be listed first on the feed tag. For example, a commercial feed mixture containing a high percentage of cottonseed hulls and a small percentage of soybean meal must list the hulls (a special emphasis ingredient in this example) first. The tag on pet foods must list the ingredients in order from the larger amount to the lesser amount. Most feed manufacturers of commercial feeds list the ingredients of a feed on the tag in order from the primary to the secondary ingredients. With the above information, a producer should be able to determine the value of a commercially mixed feed with some degree of accuracy.

Manufacturers of commercial feeds sold in bulk, except customer-formula feeds, must register the feed before it is offered for sale and must furnish the purchaser a printed or written statement giving about the same information as is shown on the label.

The Oregon Department of Agriculture has state inspectors who take samples of commercial feeds and fertilizers. These samples are analyzed to determine whether the manufacturer is meeting the guarantee expressed on the tag. Annually, a report listing samples taken, firms, brands, and violators is published by the State Department of Agriculture.

5. Preparation of Feeds

The assumption that the preparation of a feed or a feed ingredient will increase the value of the feed or ingredient is unfounded; however, the preparation of feed may increase consumption, improve digestion, eliminate waste, increase palatability, make the feed easier to handle, and make it easier to feed. It is also possible to decrease the value of a feed through improper preparation. Feed should be prepared for one of the above reasons and not to eliminate the animal's having to chew it. Generally, animals are capable of chewing and digesting feeds without special preparation.

The value of feed preparation and the method of preparation to use will depend upon the feed, the age of the animal, the kind of animal, and the cost of the preparation. An explanation of the more common methods of feed preparation is given below.

Grinding

The grinding of grains is a practice that has been followed for

many years; however, to be profitable, the producer or feed mill operator should grind grains only when it will increase digestion or consumption, or when the grain has a hard coat which makes it difficult for the animal to chew. Grains should be coarse ground and have a gritty or mealy feel to the touch after grinding. Finely ground grain (floury feeling) are difficult for the animal to digest and will increase the grinding cost by increasing the power requirements for grinding. The grinding of roughages is recommended only when it will increase consumption, eliminate waste, or when it is being mixed with concentrates.

Cubing and Pelleting

Most feeds and feed mixtures can be cubed or pelleted. Cubing or pelleting will increase consumption, eliminate waste, make feeds easier to handle, and require less feeding equipment. If one of the above advantages will offset the additional cost, the producer should feed cubes or pellets.

Steam Flaking of Grains

Steamed flaked grains are steamed and run through rollers that have a 1/16 inch opening. Most authorities believe steam flaking will increase digestibility of milo, and the digestibility of corn might be improved. There are few benefits derived from flaking wheat or barley. The quality of flakes is important. The higher quality is found in thinly flaked grains.

Wafering Roughages

Some producers are feeding roughage wafers; wafers are easier to handle, easier to feed, eliminate waste and require less storage space. If the cost of wafering is offset by one of the above advantages, wafers should be fed.

Cooking and Soaking Grains

The advantages of cooking or soaking grains are questionable. Either preparation requires special equipment and additional labor.

6. Nutritive Requirements of Livestock

Feeding standards have been developed by scientists to serve as guides for livestock producers to determine the nutritive requirements of animals. There may be considerable differences in composition and feeding value of two lots of the same kind of feed, and there is considerable variation in animals' ability to digest and utilize feeds. It is reiterated that the feeding standards are only guides. Even though a ration may meet the animals' nutritive requirements listed in the standard, this does not necessarily mean that the ration is a good one.

Feeding standards for all classes of animals are listed in Table III of Morrison's Feeds and Feeding. Much of the same information may be obtained from Feeds and Nutrition, Ensminger and Olentine, 1978. To determine an animal's nutritive requirements, one must know the approximate weight of the animal. After the class and weight of the animal is found in Table III, one should read across the table to find the animal's other nutritive re-

quirements. For example, the daily requirements of a 600-pound fattening baby calf, according to Table III, Morrison's Feeds and Feeding, Ninth Abridged Edition, are shown in transparency number seven.

Transparency No. 7

Note: Teacher may use a wax pencil on the above transparency to figure the ration by the total digestible nutrient method.

A 600-pound fattening baby beef should have a digestible tract large enough to consume from 13.2 to 15.8 pounds of dry matter; and this amount of feed should furnish the amount of digestible protein (1.26 - 1.37) and total digestible nutrients (10.2 - 11.8) required by the animal.

A range is given in the standard to allow for economic conditions, which will determine whether the lower or higher figures in the standard are used. To secure the best results, Morrison recommends the higher figure; however, a ration composed of desirable feeds which meet the requirements of the animal should be adequate.

Prior to computing the ration, the producer should have in mind the approximate amounts of concentrates and roughages required by various animals. The "rules of thumb" given in section 2 of this topic should assist in determining these amounts.

7. Computing Rations

An explanation of two methods of figuring rations will be given. The first method to be explained is the total digestible nutrient method.

Since the requirements for a 600-pound fattening baby beef are given in the previous transparency, these requirements will be used.

After the requirements of the animal or the average animal in the herd have been listed in tabular form, the producer is ready to try to balance the ration. It is known that the animal can consume 13 to 16 pounds of feed; and according to the "rules of thumb", beef animals can be fed 2 or more pounds of concentrates and roughages for each 100 pounds of body weight per day, so this animal may be fed from 12 to 16 pounds of feed.

The next step is to determine the kinds and amounts of feed to use in the ration. The producer may select milo as the major grain in the ration, if it were the cheapest grain available. In addition, other feeds will have to be selected for the ration. The composition of various feeds is found on pages 538 - 619 in Morrison's Feeds and Feeding, Ninth Abridged Edition.

To meet the requirements of the 600-pound baby beef, the sample ration will include 9 pounds of milo, 5 pounds of cottonseed hulls, and 2 pounds of 41 percent protein analysis cottonseed meal.

Transparency No. 8

The composition of each nutrient in each feed is multiplied by the number of pounds of each feed used in the ration, and the nutrients are totaled.

The feeds selected above as a ration will provide the nutritive requirements of a 600-pound fattening baby beef. The digestible protein exceeds the requirement but isn't enough to affect the animal. It should be noted that this is only an example.

The next step is to determine the mineral requirements of the animal. The calcium, phosphorus, and carotene content of the above ration are deficient, but the feeder may provide minerals in the ration or in a feed choice mineral feeder.

It may be necessary to adjust the amounts of feeds used in the ration in order to meet the animal's nutritive requirements. If the ration is low or all of the feed low in protein; and if the ration is low in T.D.N., a concentrate high in T.D.N. will need to be substituted for all or a part of the low T.D.N. feed (s). The cost of each ingredient in the ration should be considered when adjusting the ration to meet the animal's nutritive requirements.

As was stated earlier, it is not necessary to figure a ration for each animal in the herd, and the ration may be figured to meet the requirements of the average animal in the group of herd. The amount of concentrates and roughages fed may be varied to meet each individual animal's requirements.

In a feed lot all the animals in a pen are generally fed the same ration; the larger animals consume more feed than the smaller ones; thereby, each animal receives its requirements.

8. Figuring a Ration for a Lactating Dairy Cow

Rations for lactating dairy cows and other classes of livestock are figured in the same way as the above example. However, the nutritive requirements are dependent upon the number of pounds of milk produced daily and the butterfat content of the milk.

The nutritive requirements of dairy cattle are determined by adding their nutritive requirements for maintenance and production. Also, cows in the last 2 or 3 months of pregnancy should receive an additional allowance.

Transparency No. 9

The requirements for a 1,100-pound dairy cow producing 40 pounds of milk having 4 percent butterfat will be used as an example. As is shown on page 625 in Feeds and Feeding, the maintenance requirements are .65 - .71 digestible protein and 7.6 - 8.6 total digestible nutrients. The nutritive requirements for 1 pound of milk are multiplied by the number if pounds of milk given by the cow. The totals for milk production are added to the cow's maintenance requirements. If the cow is in the last 2 or 3 months of pregnancy, these nutritive requirements should be included in the total requirements. After the requirements have been determined, the ration for the lactating cow is figured in the same manner as was the 600-pound fattening baby beef.

9. Computing Rations by the Pearson's Square

The Pearson's square, another method of figuring rations, is a simplified method that may be used in several different ways. Either the crude or digestible protein requirements of the animal are used to figure rations by this method. Approximately 80 percent of the crude protein requirements are used in figuring the rations it should be about 20 percent greater than if the digestible protein requirements are used. For example, an animal requiring a 16 percent crude protein ration would require a ration containing 13 percent digestible protein. Since digestible protein was used to figure the rations by the T.D.N. method, it will be used with the square method.

The first example, using the square method, will be to determine the number of pounds of milo and 41 percent cottonseed meal needed to formulate a 13 percent digestible protein mixture. The following steps should be used:

Transparency No. 10

(1) A square is drawn with lines connecting opposite corners.
(2) In the center of the square where the diagnals cross, the percent of protein desired in the mixture is entered.
(3) To the left of the upper left hand corner of the square, the grain (milo) and its protein content should be listed.
(4) To the left of the lower left hand corner of the square, the higher protein feed (cottonseed meal) and its protein content are listed.
(5) Subtract along diagonal lines the smaller number from the larger number and place the difference at the opposite end of the diagonal lines. 13 - 8.5 = 4.5, and 32.2 - 13 = 19.2.

The difference between the protein percentage in the cottonseed meal (32.2) and the protein percent desired in the ration (13) is the number of parts of milo needed (19.2). The difference between the protein percent of the milo (8.5) and the percent of protein desired in the ration (13) is the number of parts of cottonseed meal (4.5) needed in the ration. The number of parts of milo and the number of parts of cottonseed meal should be added to get the total parts in the mixture, (23.7).

(6) To find the percentage of each feed in the mixture, one should divide the parts of each by the total parts.

Milo 19.2 ÷ 23.7 = .81 = 81 percent
Cottonseed meal 4.5 ÷ 23.7 = .19 = 19 percent

In order to have 13 percent protein mixture using milo and cottonseed meal, the producer would mix 81 pounds of milo with 19 pounds of cottonseed meal.

Another way in which the square may be used to figure a ration is as follows:

Assume a ration is needed for a 600-pound yearling wintering beef heifer with an expected 1/2 to 3/4 pound of daily grain.

Also assume that the producer has a roughage and concentrates and would like to feed one pound of roughage for each 100 pounds of body weight.

Transparency No. 11

The following steps should be taken to figure the ration:

(1) The nutritive requirements are determined from the feeding standards.

(2) The amount of digestible protein and T.D.N. supplied by the roughage is determined and subtracted from the total requirements. The remainder or deficit nutrients must be supplied by the concentrates.

(3) The pounds of deficit T.D.N., 4.3 (determined in step 2) is divided by 80 (the approximate percentage of T.D.N. in the concentrate mixture to be used) and multiply by 100. This will give the pounds of concentrate required.

$$\frac{\text{Deficit T.D.N.}}{\text{\% T.D.N. in concentrate}} \times 100 = \text{pounds of concentrate mixture required}$$

(4) The deficit pounds of digestible protein (determined in step 2) are divided by the pounds of concentrates to be fed (determined in step 3) and multiplied by 100 to find the percent of digestible protein needed in the concentrate mixture.

$$\frac{\text{Deficit lbs. D.P.}}{\text{Pounds of COncentrate Required}} \times 100 = \text{percent of D.P needed in the concentrate mixture.}$$

(5) The proportion of protein supplement and grain, or grain mixture needed to provide the desired percent of D.P. in the concentrate mixture is determined by using the square.

The ration should also provide minerals.

Transparency No. 12

The square may also be used to figure a complete ration. The steps are as follows:

(1) The protein requirements for the average animal to be fed are determined. Assume that a 10 percent digestible protein ration is needed.

(2) The protein requirement is placed in the square where the diagonals cross.

(3) The mixture of grains and/or roughages that will be included in the ration are listed to the left of the upper left hand corner of the square, and the protein (s) to the left of the lower left hand corner of the square.

(4) The pounds of grains and/or roughages and the pounds of protein provided by each are added, and the pounds of protein feed (s) and total pounds of protein furnished are added.

(5) The protein in the grains and/or roughages are divided by the total number of pounds in the mixture. This will give the average protein content of the grains and/or roughages.

(6) The protein in the protein feed (s) are divided by the total number of pounds in the mixture.

(7) The smaller number is subtracted diagonally from the larger. This is the number of parts of grain and/or

roughage mixture and protein mixture needed in the ration.

(8) The parts of concentrates and/or roughages are added to the part (s) of protein to determine the total parts in the ration. Then, the parts of grain and/or roughage are divided by the total parts and multiplied by 100 to determine the percentage of grain and/or roughage in the ration.

22 ÷ 27 = .81 or 81 percent
5 ÷ 27 = .19 or 19 percent

Eighty-one pounds of the milo-cottonseed hulls mixture are mixed with 19 pounds of cottonseed meal to get a 10 percent digestible protein ration.

ESSENTIALS OF A GOOD RATION

1. Nutrients should be balanced

2. Ration should contain a variety of feeds

3. Ration should be succulent

4. Ration should be palatable

5. Ration should be bulky

6. Ration should be slightly laxative

7. Ration should be economical

8. Ration should be suited to animal

Ag II - V - 50

ESSENTIAL AND NON-ESSENTIAL AMINO ACIDS FOR SWINE

Essential	Non-essential
Arginine	Alanine
Histidine	Aspartic Acid
Isoleucine	Citrulline
Leucine	Cystine
Lysine	Glutamic Acid
Methionine	Glycine
Phenylalanine	Hydroxyglutamic Acid
Threonine	Hydroxyproline
Tryptophan	Norleucine
Valine	Proline
	Serine
	Tyrosine

COMPARISON OF THE VALUE OF CORN AND MILO BASED ON THEIR T.D.N. CONTENT

	COST	T.D.N.
CORN	$ 6.30 per cwt	80.1
OATS	$ 5.50 per cwt	70.0

6.30 ÷ 80.1 = .0787 per lb × 100 = 7.87 per cwt of T.D.N. for corn

5.50 ÷ 70 = .0785 per lb × 100 = 7.85 per cwt of T.D.N. for oats

OATS ARE SLIGHTLY CHEAPER BASED ON COST PER 100 LBS OF T.D.N.

THE T.D.N. USED FOR CORN AND OATS IS BASED ON THEIR VALUE FOR RUMINANTS

NUTRITIVE REQUIREMENTS FOR CHICKENS

	STARTING CHICKENS 0 - 8 Weeks	GROWING CHICKENS 0 - 12 Weeks	LAYING HENS	BREEDING HENS
TOTAL PROTEIN, PERCENT	20	16	15	15
VITAMINS				
VITAMIN A ACTIVITY (U. S. P. UNITS)*	1,200	1,200	2,000	3,300
VITAMIN D (INTERNATIONAL CHICK UNITS)	90	90	225	340
B-COMPLEX VITAMINS, THIAMIN, MG.	0.8	?	?	?
RIBOFLAVIN, MG.	1.3	0.8	1.0	1.7
PANTOTHENIC ACID, MG.	4.2	4.2	2.1	4.2
NIACIN, MG.	12	?	?	?
PYRIDOXINE, MG.	1.3	?	1.3	1.3
BIOTIN, MG.	0.04	?	?	?
CHOLINE, MG.	600	?	?	?
FOLACIN, MG.	0.25	?	0.11	0.16
B-12, MG.	0.004	0.004	?	0.002
MINERALS				
CALCIUM, PERCENT	1.0	1.0	2.25**	2.25**
PHOSPHORUS, PERCENT	0.6	0.6	0.6	0.6
SALT, PERCENT	0.25-0.50	0.25-0.50	0.5	0.5
POTASSIUM, PERCENT	0.2	0.16	?	?
MANGANESE, MG.	25	?	?	15
IODINE, MG.	0.5	0.2	0.2	0.5
MAGNESIUM, MG.	220	?	?	?

* May be Vitamin A or Carotene.

**This may not be needed in the mixed feed because calcium supplements are usually fed free-choice.

GRAIN SUBSTITUTION OR COMPARISON CHART

BEEF CATTLE AND SHEEP

	Cost of 100 lbs.					
Corn	4.64	5.00	5.36	5.72	6.08	6.42
Milo	4.34	4.66	5.00	5.34	5.66	6.00
Wheat	4.46	4.80	5.16	5.50	5.84	6.20
Oats	4.00	4.32	4.62	4.88	4.48	5.38
Barley	4.10	4.50	4.76	5.12	5.40	5.66

SWINE

Corn	4.64	5.00	5.36	5.72	6.08	6.42
Milo	4.1o	4.50	4.82	5.14	5.46	5.78
Wheat	4.86	5.26	5.64	6.00	6.40	6.74
Oats	3.94	4.26	4.56	4.88	5.18	5.44
Barley	4.20	4.54	4.88	5.20	5.54	5.80

DAIRY CATTLE

Corn	4.28	4.64	5.00	5.36	5.72	6.08
Milo	4.28	4.64	5.00	5.36	5.72	6.08
Wheat	4.30	4.64	5.00	5.36	5.70	6.06
Oats	4.06	4.44	4.76	5.06	5.44	5.76
Barley	4.30	4.62	5.00	5.38	5.70	6.08

COMMERCIAL FEED TAG (LABEL EXAMPLE)

a. 100 pounds (net)

b. Red Steer Feeds calf concentrate - 32

c. MEDICATED

d. For maintaining weight gains and feed efficiency

e. DIRECTIONS FOR USE Use at the rate of 10 pounds per 100 pounds of concentrate when feeding to calves

f. ACTIVE DRUG INGREDIENTS Ampicillin

g. GUARANTEED ANALYSIS

crude protein, not less than	32.0 %
crude fat, not less than	3.0 %
crude fiber, not more than	7.0 %
calcium (ca), not more than	1.0 %
phosphorus (p), not less than	1.1 %

h. INGREDIENTS

Plant protein products, animal protein products, processed grain by-products, dehydrated alfalfa meal, etc.

i. MANUFACTURED BY
DOE MILLING CO.
DOE, TX 77777

NUTRITIVE REQUIREMENTS FOR A 600 LB. FATTENING BABY BEEF

	Dry Matter	Digestible Protein	Total Digestible Nutrients
600 lb. Baby Beef	13.2 - 15.8	1.26 - 1.37	10.2 - 11.8

TM - 7

SAMPLE RATION FOR A 600 LB. BABY BEEF

1# MILO	.89	.085	.794
	9 POUNDS	9 POUNDS	9 POUNDS
	8.01	.765	7.14
1# C. S. HULLS	.908	0	.437
	5 POUNDS	5 POUNDS	5 POUNDS
	4.54	000	2.18
1# C. S. MEAL	.922	.322	.691
	2 POUNDS	2 POUNDS	2 POUNDS
	1.84	.644	1.38

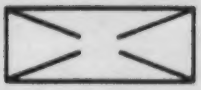
REQUIREMENTS FOR	D.M.	D.P.	T.D.N.
600 LB. BABY BEEF	13.2 - 15.8	1.26 - 1.37	10.2 - 11.8
9 LBS. OF MILO	8.01	.765	7.14
5 LBS. COTTONSEED HULLS	4.54	----	2.18
2 LBS. COTTONSEED MEAL	1.84	.644	1.38
	14.39	1.40	10.7

DETERMINING NUTRITIONAL REQUIREMENTS FOR A DAIRY COW

	Digestible Protein	Total Digestible Nutrients
1,100 lb. Lactating dairy cow for maintenance	.65 - .71	7.6 - 8.6
For Milk Production for each pound of 4.0% milk	.041 - .049 40 40 1.640 -1.960	.31 - .32 40 40 12.40 -12.80
Requirements for a 1,100 lb. cow giving 40 lbs. of 4.0% milk	2.29 - 2.67	20.00 - 21.40
This amount should be added if the cow is in the last 2 to 3 months of pregnancy	.65 - .70	6.5 - 7.0

USING THE SQUARE TO FIGURE RATIONS

STEP No. 1



STEP No. 2

MILO 8.5

STEP No. 3 AND 4

C.S.M. 32.2

MILO 8.5 — 19.2 PARTS OF MILO

STEP No. 5

C.S.M. 32.2 — 4.5 PARTS OF C.S.M.

TOTAL PARTS IN MIXTURE 23.7

STEP No. 6

MILO	19.2	23.7 = .81 x 100 =	81%
COTTONSEED MEAL	4.5	23.7 = .19 x 100 =	19%

USING THE SQUARE TO FIGURE A RATION FOR A 600 LB. WINTERING BEEF HEIFER

STEP No. 1 FEEDING STANDARD REQUIREMENTS FOR HEIFER

	D.M.	D.P.	T.D.N.
600 LBS. WINTERING BEEF HEIFER	11.6-13.3	.67-.75	6.3-7.2

STEP No. 2

COMPOSITION OF:			
1 LB. OF SUDAN HAY	.894	.043	.486
6 LBS. OF SUDAN HAY	x 6	x 6	x 6
PROTEIN AND T.D.N. SUPPLIED IN 6 LBS OF HAY	XXX	.258	2.916

PROTEIN AND T.D.N. TO BE SUPPLIED IN CONCENTRATES, OR DEFICIT PROTEIN AND T.D.N. .49 - 4.3

STEP No. 3 4.3 80 = .054 x 100 = 5.4 LBS. = POUNDS OF CONCENTRATES REQUIRED

STEP No. 4

.09
5.4 .490

x 100 = 9.0 OR 9.0 - PERCENT OF DIGESTIBLE PROTEIN NEEDED IN CONCENTRATE MIXTURE

STEP No. 5

GRAIN

PROTEIN

TOTAL PARTS

USING THE SQUARE TO FIGURE A COMPLETE RATION

(A 10 PERCENT DIGESTIBLE PROTEIN RATION IS NEEDED)

STEP No. 1

STEP No. 2

9 POUNDS MILO
5 POUNDS COTTONSEED HULLS

1 POUND COTTONSEED MEAL

STEP No. 3

MILO 9 POUNDS - .765
COTTONSEED HULLS
5 POUNDS - .000
.765

COTTONSEED MEAL
1 POUND 32.2
32.2

STEP No. 4

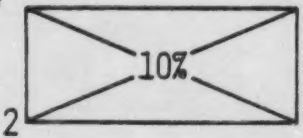
5.4 AVERAGE PROTEIN
14 .765

STEP No. 5

32.2 AVERAGE PROTEIN
1 32.2

STEP No. 6

5.4



32.2

22.2 PARTS OF MILO AND COTTONSEED HULLS

4.6 PARTS OF MEAL
26.8 OR 27 POUNDS

STEP No. 7

22 27 = .81 OR 81 PERCENT MILO AND COTTONSEED HULLS MIXTURE

5 27 = .19 OR 19 PERCENT COTTONSEED MEAL

Composition and Classification of Feeds

Assignment Sheet #1 - Determining TDN and DP Content of Basic Feeds

Using Morrison Feeds and Feeding (Table I), calculate the TDN and DP of the following feeds.

I. How many pounds of TDN are there in:

A. 50 pounds of No. 1 yellow corn

B. 30 pounds of milo grain

C. 50 pounds of wheat, average all types

D. 50 pounds of oats, Pacific states

E. 20 pounds of alfalfa hay, all analysis

II. How many pounds of DP are ther in each of the above pounds of feed?

A.

B.

C.

D.

E.

Composition and Classification of Feeds

Assignment Sheet #2 - Balancing Rations Using Pearson's Square

Determine the total parts needed in a 16% ration using 8.5% DP milo and 41.0% cottonseed meal. Show your work.

Composition and Classification of Feeds

Assignment Sheet #3 - Working A Sample Ration For A Fattening Beef Animal

Balance a sample ration for an 800-pound beef fattening animal for DM, TDN, and DP. Use Morrison Feeds and Feeding for reference.

Animal requirements	DM	DP	TDN

Use the following grains:

Corn dent grade #1 -

Soybean meal 41% -

Barley -

Composition and Classification of Feeds

Assignment Sheet #4 - Working A Sample Ration for Fattening Swine

Balance a sample ration for a 125 - pound swine fattening animal for DM, DP, and TDN. Use Morrison Feeds and Feeding for reference.

Animal requirements	DM	DP	TDN

Use the following grains:

Wheat, average all types -

Corn dent grade #1 -

Soybean meal 41% -

Composition and Classification of Feeds

Answers to Assignment Sheets

Assignment Sheet #1

I. a. 40.9 lbs. TDN
b. 23.8 lbs. TDN
c. 40.0 lbs. TDN
d. 36.1 lbs. TDN
e. 10.1 lbs. TDN

II. a. 3.45 lbs. DP
b. 2.55 lbs. DP
c. 5.55 lbs. DP
d. 3.50 lbs. DP
e. 2.18 lbs. DP

Assignment Sheet #2

I. 25.0 Parts of milo
7.5 Parts of cottonseed meal
33.5 Total parts

Assignment Sheets #3 and #4 - Instructor to supply answers.

Animal Nutrients

Sample Quiz #1

1. Match the following terms with the appropriate definitions on the right.

_____ a.	Feed additives	1. Complex chemicals essential for normal body functions
_____ b.	Proteins	2. Building blocks of protein
_____ c.	Vitamins	3. Elements which are necessary for proper body functions and life processes
_____ d.	Minerals	4. Nutrients which supply building material for body growth and repair
_____ e.	Amino acids	5. Carbohydrates which supply energy to animals
_____ f.	Starches	6. Substances added to a ration to perform a specified function

2. Name the six major nutrients.

a.

b.

c.

d.

e.

f.

3. From the list below, place a "P" in front of each plant protein and an "A" in front of each animal protein.

_____a. Tankage

_____b. Soybean meal

_____c. Cottonseed meal

_____d. Fish meal

_____e. Meat scraps

_____f. Linseed meal

_____g. Dried milk products

4. Match the feed nutrients on the left with their appropriate function on the right. All functions may be used.

_____a.	1. Develops skin tissue
_____b.	2. Develops nerve tissue
_____c.	3. Source of energy
_____d.	4. Removes waste material
_____e.	5. Regulates body temperature
_____f.	6. Stores energy in body
	7. Insulation
	8. Skeletal structure

5. Which materials listed below are considered major minerals? Place an "X" beside each major nutrient.

   a. Sulfur _____
   b. Potassium _____
   c. Cobalt _____
   d. Calcium _____
   e. Iodine _____
   f. Iron _____
   g. Phosphorus _____

6. Name three minor minerals.

   a.

   b.

   c.

7. Match the minerals on the left with their appropriate source on the right. All sources given may be used.

_____	a. Calcium	1.	Trace mineralized salt
_____	b. Phosphorus	2.	High Forage ration
_____	c. Potassium	3.	Salt
_____	d. Sodium chloride	4.	Steamed bone meal
_____	e. Iron	5.	Rock phosphate
		6.	Good quality roughage

8. Match the vitamins on the left with their appropriate source on the right. Sources may be used twice, and all sources given may be used.

_____	a. Vitamin A	1.	Green plants and cereal grain
_____	b. Vitamin B	2.	Sun cured hay
_____	c. Vitamin D	3.	Fish oil
_____	d. Vitamin E	4.	Produced in rumen (Commercial sources)
_____	e. Vitamin K	5.	Dehydrated alfalfa meal
		6.	Good quality alfalfa hay

9. Name four sources of protein in animal nutrition.

   a.

   b.

   c.

   d.

10. Match the minerals with their deficiency symptom by placing the number of the deficiency by the mineral.

_____	a.	Calcium	1. Lameness
_____	b.	Phosphorus	2. Anemia
_____	c.	Potassium	3. Rickets
_____	d.	Iron	4. Hairless pigs
_____	e.	Manganese	5. Goiter
_____	f.	Iodine	6. Abortion
			7. Stiffness

11. Match the sources on the right with their appropriate nutrients.

_____	a.	Carbohydrates	1. Tallow
_____	b.	Fats	2. Cereal grains
			3. Molasses
			4. Animal Fats
			5. Seeds

12. Match the deficiencies on the right with the vitamins on the left. All deficiencies may be used.

_____	a.	Vitamin B	1. Internal bleeding
_____	b.	Vitamin D	2. Muscular weakness
_____	c.	Vitamin K	3. Loss of young
_____	d.	Vitamin A	4. Rickets
_____	e.	Vitamin E	5. Blindness

13. Name two purposes of growth stimulants as a feed additive.

a.

b.

14. Why are antibiotics used as a feed additive?

15. Name two antibiotics most commonly used as feed additives.

a.

b.

16. Name two growth stimulants.

a.

b.

Animal Nutrients

Answers to Quiz #1

1. a. 6
   b. 4
   c. 1
   d. 3
   e. 2
   f. 5

2. a. Water
   b. Carbohydrates
   c. Fats
   d. Proteins
   e. Vitamins
   f. Minerals

3. a. A
   b. P
   c. P
   d. A
   e. A
   f. P
   g. A

4. a. 3
   b. 3
   c. 3,6,7
   d. 1,2
   e. 8
   f. 4,5

5. a. X
   b. X
   c.
   d. X
   e.
   f.
   g. X

6. Any three of the following:
   a. Iron
   b. Copper
   c. Zinc
   d. Iodine
   e. Cobalt
   f. Magnesium

7. a. 6,5
   b. 4,5
   c. 2
   d. 3
   e. 1

8. a. 5,6
   b. 4
   c. 2
   d. 1,6
   e. 4

9. Any four of the following:
   a. Cottonseed meal
   b. Linseed meal
   c. Soybean meal
   d. Skim milk
   e. Tankage
   f. Alfalfa hay

10. a. 3
    b. 1,7
    c. 7
    d. 2
    e. 6,7
    f. 4,5

11. a. 2,3
    b. 1,4,5

12. a. 2
    b. 4
    c. 1
    d. 5
    e. 3

13. a. Stimulate weight gain
    b. Reduce feed required per unit of gain

14. To increase weight gain and to help control disease.

15. Any two of the following:
    a. Aueromycin
    b. Terramycin
    c. Penicillin
    d. Streptomycin

16. Any two of the following:
    a. Stilbestrol
    b. Progesterone
    c. Testoserone

Composition and Classification of Feed

Sample Quiz #2

1. Define the following terms.
   a. Silage -

   b. Supplement -

   c. Concentrate -

   d. Ration -

   e. Fiber -

   f. Protein -

2. Complete the following chart showing the composition of feeds.

   a. Water b. _____

   c. Ash d. Organic matter

   e. _____ f. _____

   g. Nitrogen free extract h. _____

   i. _____ l. Cellulose

   j. _____

   k. Starch

3. Match the following feeds to the correct category.

1. Dry roughage	1. Corn _____
2. Green roughage	2. Wheat straw _____
3. Concentrate	3. Soybean meal _____
4. Silage	4. Milo _____
	5. Alfalfa hay _____
	6. Cottonseed meal _____
	7. Wheat bran _____
	8. Sorghum forage _____

4. Name three factors that determine the value of feeds.
   a.

   b.

   c.

5. What three requirements must be stated on a commercial feed tag?

   a.

   b.

   c.

6. All feed grains contain (a) _____% water and (b) _____% dry matter.

7. In the list of sugars below, place an "S" in front of simple sugars and a "C" in front of compound sugars.

   a. _____Glucose
   b. _____Maltose
   c. _____Sucrose
   d. _____Galactose
   e. _____Fructose
   f. _____Lactose

8. Which of the following grains would be more economical.

	DP	TDN	Cost/Cwt
a. Milo	8.5	79.4	$2.00
b. Wheat	11.3	79.6	1.75

9. Balance a 16% protein ration for a growing pig, using Pearson's square.

   _____# milo

   _____# tankage

   Milo
   8.5
   Tankage
   60%

Composition and Classification of Feed

Unit II - 4 Hours

Answers to Quiz #2

1. a. The feed crops cured and stored green or without drying.
   b. Anthing which is added to a feed.
   c. The feeds which have a high proportion of digestible nutrients and not much fiber
   d. The daily feed which an animal receives
   e. The tough part of feed which is not very digestible
   f. The organic compound consisting of C, H, O, N, and S, and sometimes P and Fe

2. b. Dry matter
   e. Protein
   f. Carbohydrates and fats
   h. Crude fiber
   i. Simple sugar
   j. Compound sugar

3. 1. 3
   2. 1
   3. 3
   4. 3
   5. 1 and 2
   6. 3
   7. 3
   8. 4

4. a. Cost per pound of TDN
   b. Cost per pound of protein
   c. Cost of feed

5. a. Minimum crude protein
   b. Minimum crude fat
   c. Maximum crude fiber

6. a. 10% water
   b. 90% dry matter

7. a. S
   b. C
   c. C
   d. S
   e. S
   f. C

8. Wheat

9. 7.5# milo
   44# tankage

Animal Digestion

Sample Quiz #3

1. Define the following terms:
   a. Digestion -
   b. Mastication -
   c. Hormones
   d. Feces -
   e. Metabolism -

2. What is the difference between a simple and a compound stomach?

3. In the list below, place an "S" by the simple stomach and an "R" by the ruminant animal.

a. _____	Horse	f. _____	Goat
b. _____	Cow	g. _____	Chicken
c. _____	Pig	h. _____	Dog
d. _____	Sheep	i. _____	Rabbit
e. _____	Man		

4. What are three functions of hormones in the digestive process?
   a.
   b.
   c.

5. Discuss in writing two functions of the mouth in regard to digestion.

6. Name five glands that aid in the breakdown of feeds in digestion.

   a.

   b.

   c.

   d.

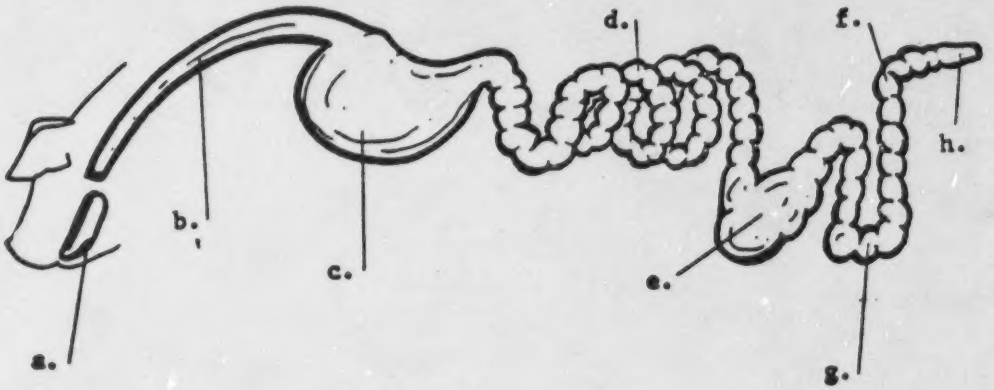
   e.

7. Chewing and grinding is considered to be _____ digestion.

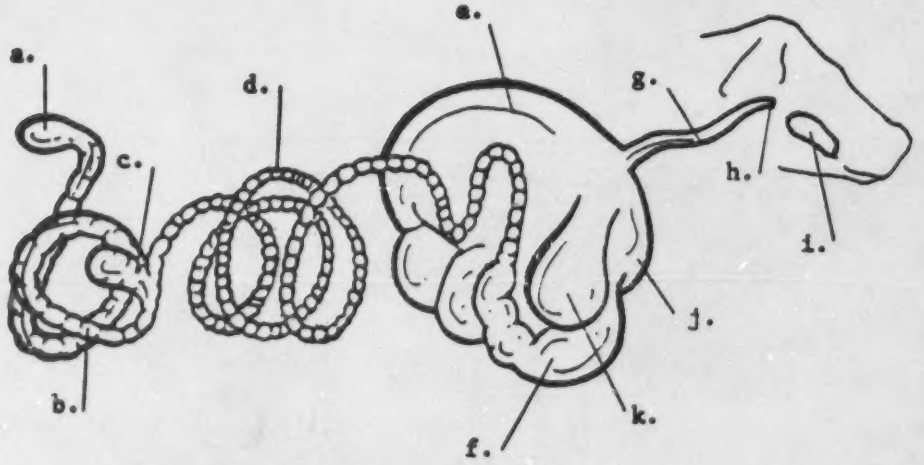
8. Mixing of feed with saliva and juices is considered to be _____ _____ digestion.

9. Identify the parts of the following drawings. (Write answers on answer sheet)

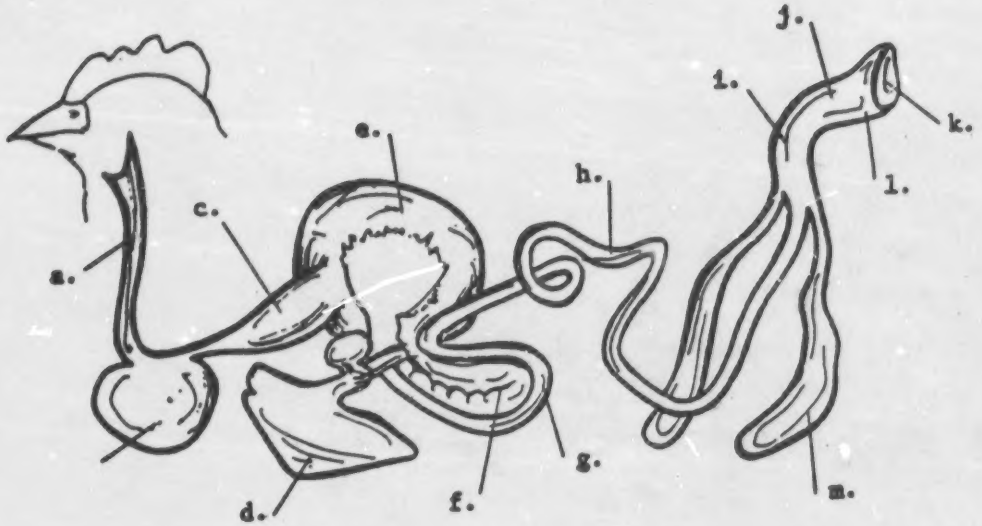
A.



B.



C.



9. A. Pig

a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

g. _____

h. _____

B. Cow

a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

g. _____

h. _____

i. _____

j. _____

k. _____

C. Chicken

a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

g. _____

h. _____

i. _____

j. _____

k. _____

l. _____

m. _____

Animal Digestion

Answers to Quiz #3

1. a. The process of preparing the food ingredients for passage into the blood stream
   b. The grinding or chewing of feed to aid in digestion
   c. The internal body secretions that regulate various body processes.
   d. The manure or the undigested material and wastes which are expelled at the end of the digestive tube
   e. The chemical change which the food undergoes within the body
2. A simple stomach has one compartment, and a compound stomach has four compartments.
3. a. S
   b. R
   c. S
   d. R
   e. S
   f. R
   g. S
   h. S
   i. S
4. Any three of the following:
   a. Digestion
   b. Metabolism
   c. Milk secretion
   d. Let-down of milk
   e. Development of sexual characteristics
5. a. Chewing or grinding of feed
   b. Secretion of saliva
6. a. Thyroid
   b. Parathyroid
   c. Pituitary
   d. Adrenal
   e. Pancreas

7. Mechanical
8. Chemical
9. A. Pig
    a. Pharynx
    b. Esophagus
    c. Stomach
    d. Small intestine
    e. Caecum
    f. Colon
    g. Large intestine
    h. Rectum

    B. Cow
    a. Anus
    b. Colon or large intestine
    c. Caecum
    d. Small intestine
    e. Rumen
    f. Abomasum
    g. Esophagus
    h. Pharynx
    i. Salivary ducts
    j. Reticulum
    k. Omasum

    C. Chicken
    a. Esophagus
    b. Crop
    c. Proventriculus
    d. Liver
    e. Gizzard
    f. Pancreas
    g. Duodenum
    h. Small intestine
    i. Large intestine
    j. Rectum
    k. Vent
    l. Cloaca
    m. Cecum

PUBLIC SPEAKING

Teachers' Use Guide

1. Allow students to choose a topic of interest to them.
2. Take 3-4 days to explain the purposes of speeches and how to write and deliver a speech.
3. Allow them 3 days to research and write their speeches.
4. Have them give speeches during class time with you critiquing them.
5. Explain judges scoresheet to the students.
6. Speech topics may arise out of units taught in Vocational Agriculture (i.e. Animal Nutrition unit -- Select a vitamin and explain what it does and why it is important to correct body function).
7. By doing suggestion #6 you can tie your units together and also allow students to help you teach technical information.
8. We realize that there is more information here than you may want to use this year. However, this is reference material for use. Select the parts you wish to use and use them.
9. We suggest the following format for a sophomore year unit on public speaking:
    a. Reasons for good speaking ability.
    b. How to write a speech.
        1) Introduction
        2) Body
        3) Conclusion
    c. Outline your speech.
    d. Give a 3-8 minute speech to the class.

References

Advisor's Handbook, Pages 107-109

Student Handbook, Page 82

FFA Manual, Page 43

Chapter Guide, Section 10

Activity Guide, Section 6

State FFA Contest Guide -- Public Speaking Contest

Objectives

Upon completion of this unit, the student will be able to:

1. Name four ways in which public speaking will benefit you today as a student and later on as a leader in your community.
2. Name three reasons for public speaking.
3. Name four advantages of being able to deliver a speech.
4. Distinguish between good speaking and bad speaking when given an example of each.
5. Match poor habits of speaking to means of improvement.
6. Select words that attract the attention of a prospective employer.
7. Name three advantages of being part of a group discussion as related to your ability to be a speaker.
8. Name three ways to improve your speaking ability.
9. Name five factors to look and listen for when evaluating someone as a speaker.
10. Name the five general intents of a speech.
11. Name the steps in developing ideas concerning a speech.
12. Name the "must do" factors for beginning speakers when preparing a speech.
13. Discuss in a short paragraph the procedures for using quotations in a speech.
14. Name three important factors to remember when using statistics in a speech.
15. Select the most frequent error used by beginning speakers when given a list of alternatives.
16. Name three factors that facilitate speech development.
17. Name four reasons for outlining a speech.
18. Name the three principal parts of an outline and arrange them in order of development.
19. Name four rules to follow when developing the main ideas of a speech.
20. Discuss in a short paragraph how the introduction is used in a speech.
21. Discuss in a short paragraph how the conclusion should blend in with the speech.
22. Name three reasons for using gestures in public speaking.
23. Name three ways of developing the proper delivery.
24. Write a sentence outline of the speech from the information collected.
25. Demonstrate the ability to write and deliver a three- to eight-minute speech to the class.

PUBLIC SPEAKING

Teaching Outline

I. Terms and definitions

A. Speech - A form of symbolism; an expression of thought, language, voice, and action; a product of the total personality.

B. Communication - A two-way process of speaking and listening.

C. Communicative Speech - A speech that is not addressed at or toward its hearers; a talk with and to its listeners.

D. Rapport - A sympathetic relationship of mutual understanding and feeling.

E. Circular response - A mechanism through which rapport is established and maintained.

F. Listening - A process of more than and different from hearing; the active co-partnership role in any act of oral communication.

G. Paraphrase - A process of taking a quotation and breaking it down into your own words.

H. FFA Public Speaking Contest - A contest held on the local, county, district, state, regional, and national levels where a student can demonstrate ability in developing skills in public speaking.

I. An outline - The logical organization of ideas which forms the framework of any story, essay, or other form of literature.

J. Gestures - The use of motions of arms or the body as a means of expressing or emphasizing an idea; an integral part of speech.

II. Communicative activities of individuals

A. Nine percent in writing

B. Sixteen percent in reading

C. Thirty percent in talking

D. Forty-five percent in listening.

III. Benefits of public speaking

A. Builds friendships

B. Exchanges information

C. Gives or asks for orders

D. Entertains others

E. Displays wit, intelligence, or information

IV. Reasons for public speaking

A. Expression

B. Communication

C. Social control

V. Advantages of speech delivery

A. Improve the art of speaking

B. Develop clearer understanding of yourself

C. Develop better understanding of other people

D. Develop more logical, orderly habits of thinking

E. Develop skill in evaluating what you hear

VI. Good speaking vs. bad speaking

A. Good speaking - occurs when the speaker is communicating with an audience

B. Bad speaking - occurs when the speaker is talking at the audience

VII.	Poor habits of speaking	Means of Improvement
A.	Careless preparation	Research and practice speech
B.	Boastfulness	Accuracy; being yourself
C.	Fault-finding	Accept constructive criticism
D.	Unsupported facts	Know what you are talking about
E.	Dull voice	Be enthused and pleasant
F.	Nervously rapid speech and/or pacing	Calm and steady rate of delivery

VIII. Key words of attention

A. Appearance

B. Personality

C. Speech

IX. Improve speaking ability

A. Speak to satisfy yourself

B. Relate speech to individual personality

C. Speech should give meaning to audience

X. Factors to consider when evaluating a speech

A. Is what the speaker saying true?

B. Does speech increase audience respect?

C. Is the speech audience-centered?

D. Does speech progress from introduction to conclusion?

E. Is audience listening to the speech or the speaker?

	Speaker's goals	Listener's response
A.	To inform	To learn
B.	To induce belief	To be convinced
C.	To move to action	To do what is urged
D.	To inspire	To feel inspired
E.	To entertain	To enjoy

XI. Speaker's goals / Listener's response

XII. Developing ideas concerning speech
- A. Start with what you know
- B. Research available references
- C. Record speech material

XIII. Factors for recording material
- A. Identify reference source
- B. Record passage acurately
- C. Record material as a single and complete unit

XIV. Rules for using quotations
- A. Do not use several quotations in speech
- B. Audience wants your opinion, not some unknown author
- C. When using quotations, use in complete text

XV. Rules for using statistics
- A. Source of information
- B. Date of information
- C. Representative value

XVI. Frequent error of beginning speaker--selecting topics that are too broad

XVII. Factors that facilitate speech development
- A. Make your speech clear
  1. Is it clear to yourself
  2. Phrase it clearly for your audience
  3. If idea is new to audience, clarify it further by definition
- B. Make your idea interesting
  1. Idea should be striking, different, and unusual
  2. Idea should be personal
  3. Idea should be concrete
- C. Make your idea significant
- D. Make your idea familiar -- getting acquainted with audience
- E. Make your idea attractive -- provide your audience with an opportunity to hear what you are saying

F. Make your idea inevitable -- speak as though your idea has got to happen

g. Make your idea appealing

XVIII. Types of outlining (Transparencies 1 and 2)

A. Sentence -- a clearer and more complete form of outline because it gives a more detailed statement

B. Topical outline -- meaning carrying words of what might have been a complete sentence

XIX. Reasons for outlining Speech

A. Reveals strength and weakness

B. Aids in organization and development of ideas

C. Reveals the proportion of the speech

D. Invaluable time-saver

XX. Principal parts of outline (Transparency 3)

A. Introduction

B. Body -- the main idea of the speech; should be developed first when preparing a speech

C. Conclusion

XXI. Rules to follow when developing main ideas

A. Should be limited in numbers

B. Should stand out clearly and emphatically

C. Should be adequate to support the theme

D. Should be arranged in the order most effective for your audience

XXII. Introduction of speech -- an attractive and motivating means of introducing the subject on which you are going to speak

(NOTE: In other words, this is a process of telling the audience what you are going to say.)

XXIII. Conclusion -- bringing together the various threads of the speech in one final effort to complete the speaker's purpose (Transparency 4)

(NOTE: In other words, tell the audience what you have talked about.)

A. Purposes

1. To give a feeling of finality to the talk

2. To clinch arguments

3. To inspire action or respect for ideas

B. Suggested methods

1. Repeat theme or main idea given earlier

2. Use appropriate story or illustration

3. Give a quotation
4. Suggest future prospects
5. Review points made

C. STOP WHEN YOU'RE FINISHED

XXIV. Ways of making a good first impression

A. Step up to lectern briskly and confidently
B. Stand behind lectern in a comfortable but erect position
C. Be clearly heard with pleasant voice
D. Let all important actions, objects, and aids be clearly seen
E. Gain and hold audience attention
F. Recognize that some fear is normal and don't let it upset you

XXV. Developing and adding meaning to delivery

A. Eye contact
B. Gestures
   1. Han
   2. Facial
C. Posture
D. Movement
E. Voice control

XXVI. Reasons for using gestures

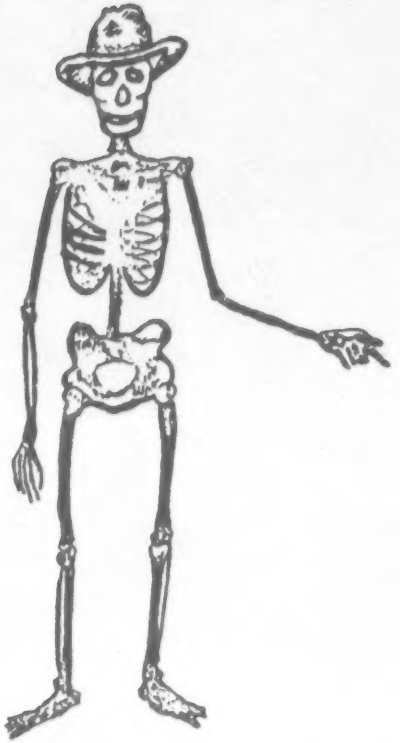
A. Signify specific thought
B. Imply attitudes or moods
C. Express thoughts and feelings

XXVII. Ways of developing proper delivery

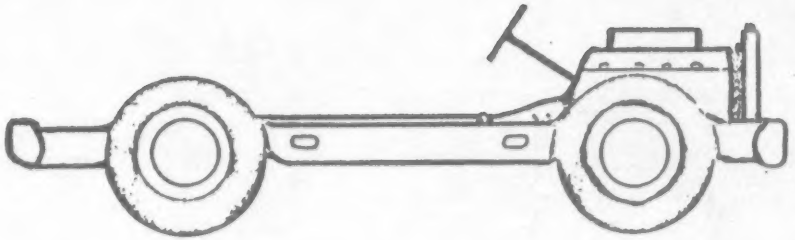
A. Stand in front of mirror
B. Use tape recorder
C. Present speech to someone

What is an Outline ?

A SKELETON



OR A FRAME



An Outline Forms The Framework Of A Story, Essay, Or Speech.

What Should an Outline Look Like?

I. INTRODUCTION
   - A. Relationship establisher
   - B. Interest gainer

II. MAIN IDEA
   - A. Revelation of central thought
   - B. Reason for giving this talk

III. BODY
   - A. First main point
     1. Subhead-Development of point
        - a. Supporting idea
        - b. Further support
     2. _____
   - B. Second main point
     1. _____
        - a. _____
        - b. _____

IV. CONCLUSION
   - A. Summary or restatement
   - B. Final punch line

Principal Parts of an Outline

I. INTRODUCTION: This arouses interest in you and indicates your appreciation of the audience.

II. MAIN IDEA: This lets the audience know what they are to hear about and prepares them for good listening.

III. BODY: This develops the main idea.

IV. CONCLUSION: This summarizes reviews, urges action, or gains respect for ideas expressed.

Conclusion

PURPOSES OF A CONCLUSION:

A. To Give A Feeling of Finality to Talk

B. To Clinch Arguments

C. To Inspire Action or Respect for Ideas

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WHEN FINISHED

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PUBLIC SPEAKING

ASSIGNMENT SHEET #1 - READ A SPEECH

Read the speech below and when completed with the reading, identify the introduction, body, and conclusion. This may be accomplished by writing a short discussion of how well you believe the three parts were written. When completed return to instructor for evaluation.

A THING CALLED LEADERSHIP
by Speaking Winner - First Place National FFA Convention
Kevin Hall

I'd like to relate to you a story of a young boy, who, when entering high school, had a burning desire to participate in school athletics. He was not the same as you and me; however, for an early childhood accident left him without the use of his arms. They hung limp at his sides, permanently crippled. He couldn't play baseball, football, or basketball. Wrestling and soccer were not for him. But there was one sport he could participate in -- track.

In his sophomore, junior, and senior years he practiced hard after school with the track squad, but he never ran in a race. He wasn't good enough! Finally, at the last meet of the year, one of his teammates took ill suddenly, and was unable to run. The boy of our story went to the coach and asked to be allowed to run in his teammate's place. Rather than lose the race by default, the coach granted permission, and as the runners took their positions in the blocks, a strange hush fell over the crowd. The gun went off, and as the runners shot up out of the blocks and down the track our boy was last. He was last going around the first turn, and last going down the far side with his arms dangling pitifully at his sides while the other sprinters constantly enlarged the lead. As this boy started around the last turn he lost his balance, tripped and fell. He got up without the use of his arms and again started to run. As he approached the finish line, the audience stood and cheered, many with tears in their eyes.

As he crossed the finish line, not only his teammates, but also his competitors greeted him and hoisted him upon their shoulders and paid tribute to him. This boy had drive, he had ambition, he had courage, he had a goal. And it is these same four qualities that are characteristic of a successful FFA member and of a leader.

But what is this thing called leadership? Leadership has almost as many definitions as there are people in the world. As defined by Webster's New World Dictionary, leadership is the "ability to lead." As outlined in the inspirational book, Forward FFA, leadership in an individual is that combination of qualities and attributes that radiates confidence, inspires others, and causes others to follow him or her.

Some people accept the philosophy that leaders are born, not made. Others believe that leaders are made not born. I belive that no man is born a leader, but that every man is born with the potential of leadership. Not every man is capable of becoming an

outstanding leader, but every man has a degree of leadership ability that should be developed and put to work.

Picture, if you would, a set of concentric circles. In the center of these circles we place a dot. The dot represents individuals, and the circles represnt the degree or actual limits of leadership ability.

Those with lesser ability lie within the first circle, those with more ability come within the second circle, and so on. It's our responsibility to push toward our potential to reach for our ultimate capability--this should be our goal.

We may never reach the outer circle -- few, if any, will. But it is there for us to strive toward each day, week, month, year and for our lifetime. Our world, our environment, and its problems are changing constantly and so will our potential.

Some worthy advise to young leaders and FFA members who are striving for this lifetime goal can be found in the words of Calvin Coolidge, who said:

> "Nothing can take the place of persistence,
> Talent will not, nothing is more common than unsuccessful men with talent,
> Education will not, the world is full of educated derelicts,
> Genius will not, unrewarded genius is almost a proverb.
> Persistence and perserverance alone are omnipotent.
> The slogan 'Press On' has solved and always will solve the problems of the human race."

W.H. Danforth, a great leader, wrote in his book I Dare You, "I dare you to be yourself, I dare you to do your best, I dare you to do better tomorrow than you have done today."

Today's youth are tomorrow's leaders -- and today's FFA members are not only going to replace those down on the farm and in other agricultural positions, but many are destined to be leaders as well. At the rate our world is changing and with the growing complexity of our problems, tomorrow's leaders will have to be more efficient, better educated, and better citizens. They will have to be more knowledgeable about our environment, more aware of our country's problems, more concerned with the world, but most of all, tomorrow's leaders will have to be squares! Squares, you ask? Because you connote square to be a degrading term or insult. But doesn't it all depend on your definition of the word square? Back in Mark Twain's day, square was one of the finest words in the English language. You gave a man a square deal if you were honest. You gave him a square meal if he was hungry. You stood foursquare for your rights, and square against all unjust oppression. And if you were out of debt you were square with the world, and then you could look your fellowman square in the eye. But this word square has been badly bent and mis-shapen, and today everyone knows what a square is:

A square is someone who volunteers when he doesn't have to, someone who starts a job and completes it to the best of his ability. Someone who has the courage to step out and take command, someone who helps his neighbor, for having the drive, the ambition, the courage to overcome any obstacles on the way to your goal, be proud you are given that distinction, for tomorrow, the world will call

upon the squares to solve the problems and assume the positions of leadership!

(NOTE: Taken from the 1970 Proceedings of the 43rd National Convention of the Future Farmers of America.)

PUBLIC SPEAKING

ASSIGNMENT SHEET #2 - SELECT SPEECH TOPIC

Study closely the different divisions of FFA Public Speaking Contest. After you have finished, select a topic on which you would like to speak. Using the identified reference, conduct as much research as possible on the topic. When completed visit with the instructor about additional information. The research should be recorded below.

PUBLIC SPEAKING

ASSIGNMENT SHEET #3 - WRITE SENTENCE OUTLINE ON SELECTED TOPIC

At this point you should begin to structure your speech in order to develop meaning and clarification. By using the information you have collected, write a sentence outline. When completed have the instructor evaluate and discuss means of improvement.

PUBLIC SPEAKING

ASSIGNMENT SHEET #4 - WRITE AND DELIVER SPEECH

Using the sentence outline written previously, write a three- to eight- minute speech. When finished with the writing, have the instructor evaluate. Study the manuscript and be able to present the context orally. The space provided below may be used for writing the speech.

PUBLIC SPEAKING

TEST

1. Match the terms on the right to the correct definition.

_____a.	An opportunity for presenting an argument for and against a proposed plan of action so that the participants and listeners may make up their minds and be prepared to vote on a certain issue	1. Speech
_____b.	A two-way process of speaking and listening	2. Rapport
_____c.	A learning process; a process of sharing the information and experiences of a group	3. Communication
_____d.	A form of symbolism; an expression of thought, language, voice, and action; and a product of the total personality	4. Debate
_____e.	A mechanism through which rapport is established and maintained	5. Discussion
_____f.	A speech that is not addressed at or toward its hearers; a talk with and to its listeners	6. Circular response
_____g.	A sympathetic relationship of mutual understanding and feeling	7. Communicative speech
_____h.	A process of more than and different from merely hearing; the active co-partnership role in any act of oral communication	8. Listening

2. An individual spends a portion of his time in speaking. From the list of alternatives, select the one that represents speaking time. Place an "X" in the blank.

_____a. Nine Percent

_____b. Sixteen Percent

_____c. Thirty Percent

_____d. Forty-five Percent

3. Name four ways in which public speaking will benefit you today as a student and later on as a leader in your community.

a.

b.

c.

d.

4. Name three reasons for public speaking.

   a.

   b.

   c.

5. Name four advantages of being able to deliver a speech.

   a.

   b.

   c.

   d.

6. Place an "X" in the blank if the statement represents an example of good speaking.

   _____a. Occurs when the speaker is talking at the audience

   _____b. Occurs when the speaker is communicating with an audience

7. Match the poor habits of speaking on the right to the correct means of improvement.

   _____a. Accept constructive criticism

   _____b. Know what you are talking about

   _____c. Research and practice speech

   _____d. Accuracy; being yourself

   _____e. Nervously rapid speech and/or pacing

   _____f. Dull voice

   1. Careless preparation
   2. Boastfulness
   3. Fault-finding
   4. Unsupported facts
   5. Calm and steady rate
   6. Be enthused and pleasant

8. Select three key words from the list of words on the right and write them in the blanks provided. These words are very important in the eyes of a prospective employer.

   a. _____

   b. _____

   c. _____

   1. Smart
   2. Appearance
   3. Height
   4. Speech
   5. Age
   6. Personality

9. Name three ways to improve your speaking ability.

   a.

   b.

   c.

10. Name five factors to look and listen for when evaluating someone as a speaker.

    a.

    b.

    c.

    d.

    e.

11. Match the speaker's goals on the right to the listener's responses.

_____a.	To learn	1. To entertain
_____b.	To enjoy	2. To inform
_____c.	To be convinced	3. To induce belief
_____d.	To feel inspired	4. To move to action
_____e.	To do what is urged	5. To inspire

12. Match the terms on the right to the correct definition.

_____a.	A contest held on the local, county, district, state, regional, and national levels where a student can demonstrate their ability in developing skill in public speaking	1. Gestures 2. Paraphrase 3. An outline 4. FFA Public Speaking Contest
_____b.	The logical organization of ideas which forms the framework of any story, essay, or other form of literature	
_____c.	The use of motions of arms or the body as a means of expressing or emphasizing an idea; an integral part of speech	
_____d.	A process of taking a quotation and breaking it down into your own words	

13. Name the five general intents of a speech.

    a.

    b.

    c.

    d.

    e.

14. Name the three steps in developing ideas concerning a speech.

    a.

    b.

    c.

15. Name the three "must do" factors for beginning speakers when preparing a speech.

    a.

    b.

    c.

16. Name the three factors to remember when recording material for a speech.

    a.

    b.

    c.

17. Discuss in a short paragraph the procedures for using quotations in a speech.

18. Name three important factors to remember when using statistics in a speech.

    a.

    b.

    c.

19. Select the statement below which represents the most frequent error used by beginning speakers. Place an "X" in the blank.

_____a. Speech topic not appropriate for speaker

_____b. Speech topic not appropriate for audience

_____c. Speech topic too broad

_____d. Introduction does not fit the body of speech

20. Name three factors that facilitate speech development.

a.

b.

c.

21. Which of the following statements identifies a topical outline? Place an "X" in the blank.

_____a. A clearer and more complete form of outline; it gives a more detailed statement

_____b. Meaning carrying words of what might have been a complete sentence

22. Name four reasons for outlining a speech.

a.

b.

c.

d.

23. Name the three principal parts of an outline and arrange them in order of development. This arrangement may be achieved by placing a number beside each part.

a. _____ Arrangement _____

b. _____ Arrangement _____

c. _____ Arrangement _____

24. Name four rules to follow when developing the main ideas of a speech.

a.

b.

c.

d.

25. Discuss in a short paragraph how the introduction is used in a speech.

26. Discuss in a short paragraph how the conclusion should blend in with the speech.

27. Name three ways of making a good first impression when giving a speech.

    a.

    b.

    c.

28. Name five ways of developing and adding meaning to your delivery.

    a.

    b.

    c.

    d.

    e.

29. Name three reasons for using gestures in public speaking.

    a.

    b.

    c.

30. Name three ways of developing the proper delivery.

    a.

    b.

    c.

31. Demonstrate the ability to:

    a. Read a speech and identify the introduction, body, and conclusion.

    b. Listen to a major speech, sermon, or talk and write a sentence outline of the speech.

    c. Select a speech topic, conduct research on the subject, and write the information down.

    d. Write a sentence outline of the speech from the information collected.

    e. Write and deliver a three- to eight - minute speech.

PUBLIC SPEAKING

ANSWERS TO TEST

1. 4 a.
   3 b.
   5 c.
   1 d.
   6 e.
   7 f.
   2 g.
   8 h.
2. c.
3. Any four of the following:
   a. Builds friends
   b. Exchanges information
   c. Gives or asks for orders
   d. Entertains others
4. a. Expression
   b. Communication
   c. Social control
5. Any four of the following:
   a. Improve the art of speaking
   b. Develop clearer understanding of yourself
   c. Develop better understanding of other people
   d. Develop more logical, orderly habits of thinking
   e. Develop skill in evaluating what you hear
6. b.
7. 3 a.
   4 b.
   1 c.

__2__ d.

__5__ e.

__6__ f.

8. a. Appearance

   b. Speech

   c. Personality

9. a. Speak to satisfy yourself

   b. Relate speech to individual personality

   c. Speech should give meaning to audience

10. a. Is what the speaker saying true?

    b. Does speech increase audience respect?

    c. Does speech progress from introduction to conclusion?

    d. Is audience listening to the speech or the speaker?

11. __2__ a.

    __1__ b.

    __3__ c.

    __5__ d.

    __4__ e.

12. __4__ a.

    __3__ b.

    __1__ c.

    __2__ d.

13. a. To inform

    b. To induce belief

    c. To move action

    d. To inspire

    e. To entertain

14. a. Start with what you know
    b. Research available references
    c. Record speech materials
15. a. Write it down
    b. Label it
    c. File it away
16. a. Identify reference source
    b. Record passage accurately
    c. Record material as a single and complete unit
17. To the satisfaction of the instructor
18. a. Source of information
    b. Date of information
    c. Representative value
19. c.
20. Any three of the following:
    a. Make your speech clear
    b. Make your idea arresting
    c. Make your idea significant
    d. Make your idea familiar
    e. Make your idea attractive
    f. Make your idea inevitable
    g. Make your idea appealing
21. b.
22. a. Reveals strength and weakness
    b. Aids in organization and development of ideas
    c. Reveals the proportion of the speech
    d. Invaluable time-saver

23. a. Introduction - 2nd

    b. Body - 1st

    c. Conclusion - 3rd

24. a. Should be limited in numbers

    b. Should stand out clearly and emphatically

    c. Should be adequate to support the theme

    d. Should be arranged in the order most effective for your audience

25. The introduction as used in a speech is to make the speech attractive and motivating; it is a means of introducing the subject on which you are going to speak

26. The conclusion is bringing together the various threads of the speech in one final effort to complete the speaker's purpose

27. Any three of the following:

    a. Step up to lectern briskly and confidently

    b. Stand behind lectern in a comfortable but erect position

    c. Be clearly heard with pleasant volume

    d. Let all important actions, objects, and aids be clearly seen

    e. Gain and hold audience attention

    f. Recognize that some fear is normal and don't let it upset you

28. a. Eye contact

    b. Gestures

    c. Posture

    d. Movement

    e. Voice control

29. a. Signify specific thought

    b. Imply attitudes or moods

    c. Express thoughts and feelings

30. a. Stand in front of mirror

    b. Use tape recorder

    c. Present speech to someone

31. Performance skills will be evaluated by the instructor.

SECTION IV
LEADERSHIP CONTESTS

A. PUBLIC SPEAKING CONTEST

This contest is designed to develop leadership abilities by providing participation in agricultural public speaking activities and stimulating interest in leadership and citizenship. Preliminary contests are of a local, district, interdistrict (sectional), state and regional character and are held under the auspices of the FFA unit concerned. These preliminary events culminate in the national contest held at the time of the FFA National Convention.

ELIGIBILITY

1. This contest is open to students less than 21 years of age at the time of their participation in the state contest, who are regularly enrolled high school vocational agriculture students and who are active members of chartered FFA chapters in good standing with the state association and the national organization. A member representing a state association in a regional or national contest is ineligible to compete in future contests.

2. The sectional contest winner will be eligible to compete in the state contest. The state winner will represent the Oregon Association in the Western Regional Contest.

GENERAL RULES AND REGULATIONS

1. EACH CONTESTANT'S SPEECH IS TO BE THE RESULT OF THEIR OWN RESEARCH AND COMPOSITION. Training in both composition and delivery is limited to the facilities of the school from which the contestant comes, but facts and working data may be secured from any source.

2. Contestants who have won the right to compete in a district, sectional or state contest, must file with the proper advisor through their teacher of vocational agriculture prior (as required by district or section) to the district or sectional contest and post-marked fourteen days prior to the state contest, the following materials:

   a. four double-spaced typewritten copies of the speech on 8-1/2 X 11" paper.
   b. a signed statement of originality of research and composition on form provided. (State Contest).
   c. a good clear glossy finished black and white phototgraph 3 X 5". (state contest)

3. A bibliography must be included as part of the public speaker's manuscript, and direct quotes from any other source of information must be marked in quotes on the manuscript and be identified in the bibliography. This applies to all contests above the local level. Failure to comply will result in disqualification.

4. Disqualification may result after results are determined and forfeiture of all awards may result.

5. Deductions of ten points will be made from the total score for each day that manuscripts are late, past post-mark, in arriving to state advisor.

6. Participants must wear official FFA dress in state contest. Twenty points will be deducted from the total score for those who fail to meet this requirement.

7. Official judges shall disqualify a contestant if he speaks on a non-agricultural subject. Contestants may choose any current subject for their speeches which is of an agricultural character (nature) and which is of general interest to the public.

8. Each speech shall be a minimum of six minutes in length and a maximum of eight minutes. Each contestant will be allowed five minutes additional time in which he will be asked questions relating to his speech. Deductions of 20 points per minute, or major fraction thereof, will be made from the score of each judge for speeches under six minutes or over eight minutes in length. (To prevent being penalized, a contestant must speak over five minutes, 30 seconds, and under eight minutes, 30 seconds.) (Major fraction = 30 seconds or more)

9. Contestants shall draw for places on the program. The program chairman shall then introduce each contestant by name only, in order of drawing and announce his speech title if desired by contestant.

10. A timekeeper shall be designated who will record the time used by each contestant in delivering his speech, noting over or under time, if any, for which deductions will be made.

11. When the contestants have finished speaking, each judge will total his score on composition and delivery for each contestant. The timekeeper's record will be used in computing the final score for each contestant. Contestants should be ranked in numerical order on basis of final score to be determined by each judge, first without consultation with each other. The judges' ranking of each contestant should be added, and the winner will be that contestant whose total ranking is the lowest.

12. Speeches are to be presented without aid of audio or visual materials except podium and/or microphone.

STATE CONTEST

1. Scoring judges for the state contest shall consist of the four second place sectional contest advisors and one selected by the state advisor from teams competing in the sectional contest.

2. It shall be the responsibility of the district advisors to notify the state advisor 14 days prior to the State Convention of the second place individual and other individual placings in the sectional contest.

3. Three impartial persons shall be selected as questioners who read the manuscript, formulate questions, and question each participant. Two copies of the questioners instructions are to be included with each manuscript.

4. Each participant will be limited to five minutes for questions. The official timer will call time at the end of the five minute question period and speaker will stop immediately.

5. Scoring judges shall not have copies of the speech manuscript in their possession during the contest. If scoring judges wish to review manuscripts, this must be done prior to or following the contest.

SECTIONAL AND DISTRICT CONTESTS

Sectional and district contests shall follow the format and/or regulations as established for the state contest. It shall be the responsibility of the district advisor, or local advisor in charge, to conduct the contest.

SCORING JUDGES INSTRUCTIONS

It is vital that the scoring judges conduct a brief orientation session prior to judging the contest, in order that they might judge the contest in a more consistent manner. The following items should be discussed and agreed upon prior to the contest:

1. The score sheet should be studied so all judges understand how it works.

2. Agree on how the score process should proceed. It is suggested that the first speaker be scored with leeway for both higher and lower scores. Succeeding speakers should then be scored on a comparative basis to the previous speaker(s).

3. Review score sheet terms and explanation of score sheet points. Copies of the national "Explanation of Score Sheet Points" should be attached to all score sheets.

4. The judges' numerical placings (1st, 2nd, 3rd, etc.), will be added to reach the final placing. See Rule 10 of General Rules and Regulations for details.

5. Agree on how to resolve tie placings.

6. Agree on where scoring judges will be seated. It is suggested that the judges spread out through the audience, so as not to influence one another and to better observe the speaker.

7. Designate one scoring judge to pick up the question forms (written comments) from all question judges. This must be done before retiring to tally scores.

8. Agree that if any scoring judges cannot hear the questions, that he will ask the questioners or the speaker to repeat the question.

9. Each judge will complete a critique form for each speech indicating both positive and negative comments.

STATE FFA PUBLIC SPEAKING CONTEST

Questioner's Instructions

Contestant's Name_____

Speech Title:_____

Judge's Name:_____

Instructions

1. The persons selected as questioners are requested to prepare three brief questions for each speech. Questions shall pertain directly to the speakers' subject. Questions with two or more parts should be avoided.

2. Questions should be prepared prior to the contest and brought to the contest in complete and legible form.

3. Please phrase opinion questions (How do your feel about ---, what is your opinion of ---, etc.), carefully, as scoring judges must grade on the basis of logic, facts, and soundness of answers.

4. Each contestant is allowed five minutes for questions. The full five minutes should be used. The questioners (3) shall rotate in putting their questions.

5. Please present this form to the designated scoring judge at the conclusion of the contest. Your comments on the answers given would be appreciated.

QUESTION 1. _____

_____

_____

QUESTIONER'S COMMENT:_____

_____

QUESTION 2. _____

_____

_____

QUESTIONER'S COMMENT:_____

_____

QUESTION 3._____

_____

_____

QUESTIONER's COMMENT:_____

_____

STATE PUBLIC SPEAKING CONTEST

Future Farmers of America

Judges Score Sheet and Rules

Explanation of Score Sheet

Part I - For Scoring Contest and Composition (To be judged from oral presentation)

1. Content of the speech includes:
   - Importance and appropriateness of subject
   - Suitability of the material used
   - Accuracy of the statements included
   - Evidence of purpose

2. Composition of the speech includes:
   - Organization of the content
   - Unity of thought
   - Logical development
   - Language used
   - Accomplishment of purpose - conclusions

Part II - For Scoring Delivery of Production

1. Voice includes:
   - Quality
   - Pitch
   - Articulation
   - Pronunciation
   - Force

2. Stage presence includes:
   - Personal appearance
   - Poise and body posture
   - Gestures
   - Eye Contact
   - Attitude
   - Confidence
   - Personality
   - Ease before audience

3. Power of expression includes:
   - Fluency
   - Emphasis
   - Directness
   - Sincerity
   - Communicative ability
   - Conveyance of thought and meaning

4. Response to questions includes:
   - *Ability to satisfactorily answer the questions on the speech which are asked by the judges indicating originality, familiarity with subject, and ability to think quickly.

5. General effect includes:
   Extent to which the speech was interesting, understandable, convincing, pleasing, and held attention.

*NOTE: Questioners should meet prior to the contest to prepare and clarify the questions to be asked.

JUDGES SCORE SHEET
STATE PUBLIC SPEAKING CONTEST--FUTURE FARMERS OF AMERICA

Part I. For Scoring Content and Composition:

Items to be scored	Points Allowed	Points awarded contestants 1	2	3	4	5	6	7	8	9	10
1. Content of the speech	200										
2. Composition of the speech	100										
Score on Content and Composition	300										

Part II. For Scoring Delivery of the Production:

Items to be scored	Points Allowed	Points awarded contestants 1	2	3	4	5	6	7	8	9	10
1. Voice	100										
2. Stage presence	100										
3. Power of expression	200										
4. Response to questions	200										
5. General effect	100										
Score on delivery	700										

Part III. For Computing the Results of the Contest:

Items to be scored	Points Allowed	Points awarded contestants 1	2	3	4	5	6	7	8	9	10
Totals of content, composition and delivery	1,000										
Less deductions for late manuscript	10 pts. day										
*Less overtime or undertime deductions, for each minute or major fraction thereof	20 pts.										
Less deduction for failure to wear official FFA dress	20 pts.										
GRAND TOTAL											
Numerical or Final placing of Contestants											

*From the timekeeper's record.

AG II
RECORD BOOK
DRAFT
BY
KEN JOHNSON

Instructor's Guide:

1. Ken Johnson has developed this draft unit. Please use it and be ready to provide input for revision.
2. Since some changes are anticipated in the current record book, a draft unit for the current book is provided.
3. When a revised book is available, a revised guide will be included.

Objectives:

Upon completion of this unit, the student will be able to:

1. Close account book.
2. Summarize records.
3. Analyze business records for production and economic efficiency.
4. Prepare and analyze a net worth statement.

Teaching Aids:

1. Record books of individual class members.
2. Transparencies of receipt and net worth statements.
3. Working copies of budget, summary, and analysis forms.

Student Activities:

1. Fill out record book on SOEP project.
2. Develop a budget for coming year.
3. Develop a business agreement for coming year.

4. Prepare closing inventory and summary.

5. Inventory capital assets.

6. Prepare net worth statements.

7. Keep records up-to-date.

References:

1. Guide for Using the Vocational Agriculture Record Book for Production Agriculture. French-Bray, Baltimore, Maryland.

2. Vocational Agriculture Record Book for Production Agriculture. French-Bray, Baltimore, Maryland.

CLOSE RECORD BOOKS:

Purpose:

For tax and accounting reasons, close the record books as soon after December 31 as possible or at end of the production cycle. Turn the record book in by January 15. The summaries are used to compute income for labor and management, and for filing income and self-employment tax returns. They are also used to study the farm business, calculate certain measures of cost and efficiency, compare your current and previous year's business, or compare yourself to state/national standards.

Explanation:

1. Read the Supervised Occupational Experience Project Agreement and see that the record book conforms to the stated agreement (e.g., type of enterprise(s), student's responsibilities, exchange labor, student's share percentage of ownership, etc.).

2. Check Inventory (Non-Depreciable) for student share percentage (shared ownership), it must not be greater than 100%.

3. Check Inventory, Depreciable Assets (Depreciable Inventory), Diary and Labor Record, and Journal to make sure the totals are accurate, complete and reasonable before posting to summaries. Check livestock numbers, feed and grain quantities, and account for all livestock, feed, and grain.

4. After a thorough check post to the appropriate summaries; Financial Summary of Enterprises, Student's Financial Summary, December 31, 19__, and Summary of SOEP.

SUMMARY OF SUPERVISED OCCUPATIONAL EXPERIENCE

1. Enterprises:

   a. Kind of Enterprise - list in order as found in inventory, depreciable assets, journal, etc., a description of the enterprise.

   b. Head/Acres - print number of head or acres for each enterprise.

   c. Total Yields - print in total yields for enterprises, e.g., lbs of meat, milk, wool for livestock; bushels or tons for grains, hay, etc.

   d. Total Receipts - transfer Journal total for the respective enterprise.

e. Total Expenses - transfer the Journal total for the respective enterprise.

f. Income - subtract receipts from income.

g. Total Hours - transfer total under respective enterprise in Labor Record.

2. Farm Improve Summary:

a. An improvement project consists of a number of jobs done over a period of time on one phase or enterprise of the home farm and will tend to increase the convenience, income, or value of that enterprise or farm. It need not be limited to the farm but also include the home, school land-livestock lab, and place of employment.

b. Examples:

1) Home -- plant shrubs/trees, repair stairs/steps, construct curbs, reseed lawn, establish garden or orchard cement work, landscape, family budget, remodel home, etc.

2) Soil -- clearing farm land, install piezometer to figure water flow and runoff, plant sod forming grasses along waterways, seed cover crop, crop rotation, etc.

3) Machinery -- establish storage area, winterizing, repair, install guard shields, safety, energy conservation, etc.

4) Farm Buildings -- electrical wiring, remodel, build additions, sound proof noise making machines, install air conditioning or heating systems, etc.

5) Pest Control -- control rodents/wildlife through chemical and deterants.

6) Drainage -- construct trapezoid ditches, outlet ditches, surface drains, install drain tiles and sumps with electric pumps, survey land so it can be leveled, etc.

7) Control of Diseases and Parasites -- drain wet spots in field, establish disease control - vaccinations, balanced rations, etc.

3. Shop Projects, Examples:

Sawhorse	Steel fence post plunger
Show stand/frame	Small motor stand
Irrigation trailer	Hydraulic wool sacker
Stock/squeez chute	Show tack
Cider press	Hanging planters
Tool box	Implement trailer
Wheel barrow	Engine hoist
Stock racks	Saddle stand
Utility trailer	Hydraulic wood splitter

4. Agricultural Skills:

   a. It is a job which can be done in a short period of time but that requires or develops skills. These jobs may be done on or off the farm and may be done alone or by helping someone trained in doing the particular job.

   b. Examples:

Castrating animals	Repair water heaters
Repair fence	Window frames
Painting	Roofs
Electrical wiring	Furniture refinishing
Plumbing	Repair machine
Carpentry	Treating wounds
Floor coverings	Plant propagation
Doors and frames	Inoculating legume seeds
Furniture repair	Finishing walls/ceilings
Pruning shrubs/trees	Glazing
Worming animals	Mortar and concrete
Trimming hooves	Soldering
Repairing household appliances	

5. Income from other Agricultural Activities:

   Write in name of employer, address, and job description; money earned (receipts), and number of days to complete the task/hours on the job.

SUMMARY OF SUPERVISED OCCUPATIONAL EXPERIENCE

Student's Name_____ Date_____ Year in Ag_____

ENTERPRISES (Supervised Occupational Experience)

Kind of Enterprise	Head Acres	Total Yields	Total Receipts	Total Expenses	Work Exp. and/or Student Labor (hrs.)	Income

FARM IMPROVEMENT SUMMARY

Improvement	Scope Head Acres	Total Student Labor Hours

SHOP PROJECTS

AGRICULTURE SKILLS

Practices Completed	Practices Completed	Practices Completed

INCOME FROM OTHER AGRICULTURE ACTIVITIES

Name Place and List Experiences	Money Earned	Days

FINANCIAL SUMMARY OF ENTERPRISES:

Purpose:

It illustrates the total net returns and return/hour of labor. Also, the student can see which enterprise is making money. This can be used as a guide in preparing next year's budget.

Explanation:

At the end of the production cycle or as soon after December 31 as possible, total the appropriate columns in the journal and inventories. Only transfer the total/to date columns for these pages. Be careful to transfer the correct figures.

Note: Total Amount, column 3, is the sum of all the enterprises.

ITEM NO.	ITEM	TOTAL AMOUNTS
1	Income (Receipts)	In the journal, add the receipt, total to date columns for Cash, CWE and Exchange (columns 5, 7, 9). Print the summation in this space.
2	Ending Inventory	
	Inventory (Non-Depreciable)	Total the End of Year Student Share Value, column 11. Print this total in this space.
	Depreciable Assets (Depreciation Schedule)	Total the End of Year Student Value, column 10, in Depreciable Assets. Print this total in this space.
3	Total Income (Receipts)	Summation of above items 1 and 2.
4	Expenses	In the journal, the expenses total to date columns (6, 8, 10), transfer their summation to this space.
5	Beginning Inventory	
	Inventory (Non-Depreciable)	Total the Beginning of Year Student Share Value, column 7, in the inventory. Print this total here.

FINANCIAL SUMMARY OF ENTERPRISES

Item No.	Item		Total Amount	Project	Project	Project	Project	Project	Project	Project
1	2		3	4	5	6	7	8	9	10
1	Income		$	$	$	$	$	$	$	$
2	End-ing Inven-tory	Non-Depreciable								
		Depreciable								
3	Total Income		$	$	$	$	$	$	$	$
4	Expenses									
5	Begin-ning Inven-tory	Non-Depreciable								
		Depreciable								
6	Total Expenses		$	$	$	$	$	$	$	$
7	Net Returns		$	$	$	$	$	$	$	$
8	Hrs Labor									
9	Return/Hr Labor									

ITEM NO.	ITEM	TOTAL AMOUNTS
	Depreciable Assets (Depreciation Schedule)	Total the Beginning of Year Student Value, column 7, for, depreciable assets. Print this total in this space.
6	Total Expenses	Summation of above items 4 and 5.
7	Net Returns	Difference between above items 3 and 6. Net returns shows the student's profit or loss for all projects -- decision time.

Note: Write in the below material under Net Returns.

8	Hours of Labor	In Labor Record, add the column totals for all the enterprises or work stations (hours). Transfer this figure to item 8, column 3 -- total amount for hours of labor.
9	Return/Hour of Labor	Divide, Net Returns, item 7, column 3, by Hours of Labor, item 8, column 3. This is the return per hour of the student's labor which is worth money.

Enterprise columns, columns 4-10, write in the work "project" on the row named "Item No." and column numbers 4-10 on the row named "1". See example. Print in the enterprise (project) within the diagonal lines. Keep the columns consistent with the other parts of this record book.

Follow the above process, except transfer only the total figures for each respective enterprise.

Once all the figures are listed, double check the student's work. Item 3, Total Amount, is the sum of all the enterprises. Therefore, Total Amount, column 3, and item 1, income = columns 4 + 5 + 6 etc., of the same item. If not, there has been an error.

STUDENT'S FINANCIAL STATEMENT:

Purpose:

It is a table that divides assets and liabilities for the student's enterprises and any other assets/liabilities they may have. The student's net worth is recorded for the beginning and end of the year, the difference is the financial growth of the student's business.

Explanation:

1. There are two financial statements: January 1, 19__ and December 31, 19__.

2. Students have liabilities, possibly hidden, such as parent's loan for the project, student labor, etc.

3. Paragraph "D", change in net worth, shows the year's financial growth.

4. Usually lending institutions require a budget and a net worth statement before they will loan money. Before visiting a lending institution, make sure that information is professional -- no spelling errors or arithmetic errors.

5. Terms:

   a. Assets - properties, items, resources, or anything of value owned by person or a business.

   b. Liabilities - financial claims against the owner or firm.

   c. Net Worth - statement listing the physical resources and liabilities of the business.

6. Examples of Assets:

   Supplies not having ready market, marketable inventories of crops and supplies, marketable securities, rifle, bike, fishing equipment, camera, stereo, etc.

7. Examples of Liabilities:

   Short-term loans coming due.

8. Uses of the Student's Financial Statement:

   a. Measures performance in terms of growth.

   b. Shows financial soundness of all businesses.

STUDENT'S FINANCIAL STATEMENT

January 1, 19___

A. NATURE OF ASSETS

Checking account at bank and cash on hand	$
Savings account at bank	$
Bonds, notes receivable, cash value life insurance, etc.	$
Value of land owned by student	$
Value of land owned in partnership (Student share)	$
Value of crops on hand owned by student	$
Value of crops on hand owned in partnership (Student share)	$
Investment in growing crops owned by student	$
Investment in growing crops owned by partnership (Student share)	$
Value of livestock and poultry owned by student	$
Value of livestock and poultry owned in partnership (Student share)	$
Value of machinery and equipment owned by student	$
Value of machinery and equipment owned in partnership (Student share)	$
Other assets (specify)	$
A. TOTAL ASSETS	$

B. NATURE OF LIABILITIES

Unpaid bills	$
Notes to be paid	$
Mortgages to be paid off	$
Other liabilities (specify)	$
B. TOTAL LIABILITIES	$

C. TOTAL NET WORTH (A - B = C) $

STUDENT'S FINANCIAL STATEMENT

December 31, 19___

A. NATURE OF ASSETS

Checking account at bank and cash on hand	$
Savings account at bank	$
Bonds, notes receivable, cash value life insurance, etc.	$
Value of land owned by student	$
Value of land owned in partnership (Student share)	$
Value of crops on hand owned by student	$
Value of crops on hand owned in partnership (Student share)	$
Investment in growing crops owned by student	$
Investment in growing crops owned by partnership (Student share)	$
Value of livestock and poultry owned by student	$
Value of livestock and poultry owned in partnership (Student share)	$
Value of machinery and equipment owned by student	$
Value of machinery and equipment owned in partnership (Student share)	$
Other assets (specify)	$
A. TOTAL ASSETS	$

B. NATURE OF LIABILITIES

Unpaid bills	$
Notes to be paid	$
Mortgages to be paid off	$
Other liabilities (specify)	$
B. TOTAL LIABILITIES	$

C. TOTAL NET WORTH (A - B = C)	$
D. CHANGE IN NET WORTH (Difference between beginning and ending)	$

c. Shows liquidity and the anticipated sources of working capital.

d. Used in acquiring credit for working capital or capital expansion.

e. Determine success or proficiency of the business.

STARTING NEW RECORD BOOK: January 1, 19__

1. In the student's confidential file photocopy the following pages for later reference.

   a. Financial Summary of Enterprises.

   b. Total Agriculture and Non-Agriculture Enterprises.

   c. Student's Financial Statements, January 1, 19__ and December 31, 19__.

   d. Summary of Supervised Occupation Experience.

   e. Future Farmer Record.

2. Transfer information from Vocational Agriculture I to Vocational Agriculture II record book.

   a. Job Calendar - providing the student keeps with the same enterprise(s) and management decisions, transfer what is applicable. For the second year, the instructor might want a more in depth job calendar.

   b. Budgets - after analyzing the Vocational Agriculture I record book summaries, make proper adjustments.

   c. Inventory (Non-Depreciable) - transfer last year's "End of Year" to new book's "Beginning of Year" for some items.

   d. Depreciable Assets (Depreciation Schedule) - transfer last year's "End of Year Student Value" to new book's "Beginning of Year Student Value."

   e. Student's Financial Statement - transfer last year's (December 31, 19__) to new book's January 1, 19__ statement.

   f. Future Farmer Record - keep continuous record and if needed, add Participation in FFA Activity.

DEPRECIATION RECORD (Depreciable Inventory)/Depreciable Assets:

Purpose:

Instead of listing these assets (capital expenditures) in the journal and accounting for their total cost in one calendar year, the costs are spread over a period of years. They are governed by federal and state tax laws. It affects the Net Income or Loss Statement (Financial Summary of Enterprises).

Explanation:

1. Depreciation record is regulated by law, there are strict rules to follow.

2. Depreciation (definition): In general, if you buy farm property, such as machinery, equipment, and/or buildings that have a useful life of more than a year, you cannot deduct its entire cost in one year. Instead, you must spread the cost over more than one year and deduct a part of its cost each year.

3. Capital expenditures are depreciable assets, payments for their purchase are made over several accounting periods (e.g., fixed assets, property, buildings, machinery, and equipment).

4. References for use with depreciable assets are the following:

   a. Farmer's Tax Guide.

   b. 1982 US Master Tax Guide.

   c. Standard Federal Tax Reporter.

5. Depreciation is a cost (expense) which is spread over a period of years. Example:

   Net Income (profit) = Income - Operating Expenses - Depreciation

   ± Change in Inventory for Resale + Value of Home Consumed Goods.

Problems with Depreciable Assets:

1. Farmers usually keep the books and let their accountants figure their taxes because the accountants are familiar with the current laws and this procedure has some safety value in the event that an individual is audited.

2. Most problems can be solved by establishing guidelines and knowing the definitions and laws for depreciable assets.

Guidelines for Vocational Agriculture Teachers:

1. $50 will be the minimum basis (purchase price/cost) for depreciable assets. If an asset costs less than $50, then it goes into operating expenses and is placed in the Journal. (Examples of such items include: one show halter, curry comb, foot rot shears, 3 hole punch, stapler, etc.)

2. Use Asset Depreciation Range (ADR -- both the Federal and Oregon governments accept it) for determining the life of a depreciable asset. Using the Asset Guideline Period for agriculture you must realize that the life of the asset cannot exceed these years but can be less than the number of years specified.

	Years
a. Machinery and Equipment	10
b. Cattle, breeding or dairy	7
c. Horses, breeding or work	10
d. Hogs, breeding	3
e. Sheep and Coats, breeding	5
f. Farm buildings	25
g. Cutting of timber -- logging machinery/equipment	6

3. Never list show equipment with a life of 20 years.

4. Valuation -- the basis (purchase price/cost) is the value used to depreciate items. To adjust for inflation, use the fair market value column in the Student's Financial Statement.

5. Different interpretations may be narrowed down by knowing the criteria and bounds of depreciation.

Three Tests for Depreciable Property:

1. It must be used in business, or to earn rent or royalty income.

2. It must be something that wears out, decays, gets used up, becomes obsolete, or loses value from natural causes.

3. It must have a useful life that can be determined and its useful life must be longer than one year. The useful life of a piece of property is an estimate of how long you can expect to use it in your business, or to earn rent or royalty income.

Criteria for Depreciation:

1. How to determine basis in the property. For property that you buy, your original basis is usually its cost to you. For property that you acquire in some other way, such as by inheriting it, receiving it as a gift, building it yourself, or getting it in a tax-free exchange, you must figure your original basis in some other way, such as fair market value, purchase price or cost.

2. When the property was placed in service (condition or state of readiness and availability).

3. Which method of depreciation you are permitted to use.

Examples of Depreciable Assets:

1. Livestock

   a. Livestock acquired for work, breeding, or dairy purposes that are not kept in an inventory account, may be depreciated.

   b. Livestock bought for draft, breeding or dairy purposes and not for sale may be inventoried, or, instead, be treated as capital assets subject to depreciation, if the method used is consistently followed from year to year.

   c. If you acquire immature livestock for draft, dairy, or breeding purposes, your depreciation will not begin until they reach maturity. Maturity is when they reach the age when they can be worked, milked, or bred.

   d. For raised breeding and dairy cows, do not claim depreciation on them because the cost of raising them has been deducted and there is no basis for income tax purposes.

   e. Feeder cattle or livestock that does not fit the definition (bred, worked, dairy) are included only in the Inventory for Resale. They are not depreciable.

2. Depreciable property:

   a. Personal property -- machinery or equipment.

   b. Real property -- anything erected on, or attached to land. <u>Land is never depreciable</u>.

3. For orchards, groves, vineyards, trees, etc., depreciation begins when trees and vines reach the income-producing stage.

4. Other Examples:

Single purpose structures (milking parlors, greenhouses, broiler production units).

Multi-purpose farm buildings.

Farm machinery and equipment (new and used).

Machinery Shed	Office Equipment
Barn	Soil Improvements
Grain Bins	Drain Tiles
Fences	Perennial Crops
Corrals	Purchased Plants
Silos	Stock for propagation
Tractor	Purchased servicing
Mower	livestock -- dairy,
Car	horse, sheep, hogs
Truck	Pumps
Trailer	Feeding Systems

Methods of Depreciation:

(Prior to 1981 tax law, for tangible property put in service before January 1, 1981, this restriction is for federal income tax only.)

There are several methods of depreciation used in agriculture. The amount of depreciation charged against an asset should equal, as near as possible, the item's loss of value. Depreciation affects taxable income. It can be a tax advantage in rapid depreciation. On the other hand, a substantially undervalued inventory can weaken seriously a farm record for management purposes. Most farmers use a combination of methods as illustrated.

Buildings -- time depreciation -- straight line method

Tractors -- moderate wear depreciation -- straight line method

Truck -- rapid wear depreciation - declining balance method

Hay baler -- very rapid wear depreciation -- double declining balance method

Straight Line Method of Depreciation (Prior to 1, Jan. 81 tax law):

1. Depreciation charges are the same each year, this is the easiest method to compute.

2. It can be used for every kind of depreciable property with a useful life of more than one year.

3. Computation:

$$\frac{\text{(Original Cost) - (Salvage/Trade-in/Scrap Value)}}{\text{No. of Years of Life}} = \text{Annual Depreciation}$$

4. Salvage/Trade-in/Scrap Value is an estimated amount that the owner will receive from sale or removal of a depreciable asset from the business.

5. Problem. Shelly purchased a dairy cow on June 24, 1979 and she claimed depreciation on this cow. Purchase price was $400, salvage value is $125, life/method/rate = 5 yrs/SL/ 1/5. Depreciation for prior years was $83, student share is 100%. Figure this year's depreciation and next year's beginning depreciable balance.

   a. Balance for Regular Depreciation: $400 - $125 = $275.

   b. Annual Depreciation: $275/5 yrs = $55/year.

   c. Depreciable Balance Beginning of Year: $275 - $83 = $192.

   d. Next Year's Beginning Depreciable Balance: $192 - $55 = $137.

Declining Balance Method:

1. The largest amount of depreciation charges are taken out the first year, with a different amount charged each year.

2. If you placed your property in service before 1981, or if your property does not qualify for ACRS, you must still use one of these methods -- straight-line or declining balance methods.

3. Property has a useful life of 3 years or more.

4. 150% declining balance is used for tangible personal property such as used machine, truck, or car used in the business.

5. 200% declining balance (double) is used for tangible personal property (except real estate) that you buy new.

6. Problem. Shelly and her Dad bought a twine baler on June 1, 1979 for $2,000 (adjusted basis). They will use the 150% declining balance method. Student share is 10%. Find this year's depreciation and end of year student value. Useful life is 5 years.

   a. Figure basic rate for 150% method:

      1/5 years x 150% = 30%

b. First Year: adjusted basis x rate = depreciation for first year

$\$2000 \times 30\% \times \frac{150}{364} = \$247$ for 1980 tax year.

Note: Purchased June 1 (41% of year).

c. Second Year:

($2000 - $247) = $1753 x 30% = $526 for 1981 tax year.

d. Student's Share: take 10% of first and second year depreciation.

Partial Year Depreciation:

Depreciation is usually done on an annual basis but it can be computed on a quarterly basis or percentage of the year basis.

As in the previous example; purchased a twine baler on June 1.

$\text{June 1} = \frac{150 \text{ days}}{364 \text{ days/year}} = .41 \times 100$ or 41%

Salvage Value. Under the declining balance method, you do not reduce the adjusted basis by the salvage value before figuring the depreciation. However, you may not depreciate property below a reasonable salvage value.

Accelerated Cost Recovery System (ACRS) (required for use by the 1981 federal tax law). Use for tangible property that you place in service after December 31, 1980 and use only for federal income tax, Oregon does not accept it.

1. This new system is relatively simple and similar to other depreciation systems. It was designed to provide incentives for business investments.

2. Examples of farm property, classified by "Recovery Period".

   a. 3-Year Property (property identified by the federal government as having a 3 year recovery period).

      1) Personal property with a guideline life of 4 years or less under the old depreciation system.

      2) Automobiles.

      3) Pickups and other light-duty trucks.

      4) Breeding hogs.

b. 5-Year Property

1) Personal property with a guideline life of 5 or more years.

2) Breeding and dairy cattle.

3) Breeding sheep and goats.

4) Farm machinery and equipment (new and used).

5) Single-purpose structures (milking parlors, greenhouses, etc.).

6) Grain bins and silos.

7) Fences.

c. 15-Year Property

1) Depreciable real property with a guideline life of more than 12 years.

2) Multipurpose farm buildings.

3. In addition to these recovery periods, the Act offers an accelerated method for computing depreciation. The method is built into tables showing the percent of the cost that can be deducted in each year. For years beyond 1984, refer to 1982 US Master Tax Guide and/or Standard Federal Tax Reporter (both published by Commerce Clearing House, Inc., Chicago, Illinois).

Tangible Property Placed in Service During 1981-1984

Recovery Year	3-Year Property, %	5-Year Property, %
1	25%	15%
2	38	22
3	37	21
4		21
5		21
	100%	100%

4. Figuring ACRS.

Unadjusted basis x certain % (table) = 1st full year depreciation

Note: useful life and salvage value are made obsolete by the ACRS.

Unadjusted basis (definition): it is the same amount you would use to compute a gain on a sale with no adjustment for any depreciation. This basis is reduced by any part you may properly amortize.

5. Problem. On January 2, 1981, Shelly and her dad purchased a dairy bull for $10,000 that they placed in service on their farm. The bull is 5-Year Property and has an unadjusted basis of $10,000. Their ACRS deduction in 1981 for this bull is 15% (from 5-Year Property/Table). Shelly's student share is 5%. Figure the deduction for Shelly during the 1981 tax year.

   Unadjusted basis ($10,000) x 15% x 5% = $75.

Alternate ACRS Method: This system gives more flexibility for recovering the cost of your property.

1. It is possible to choose a longer recovery period. The straight-line method is used to calculate the recovery allowance for each year.

ACRS Class	Alternative Recovery Periods
3-Year Property	3, 5, or 12 years
5-Year Property	5, 12, or 25 years
10-Year Property	10, 25, or 35 years
15-Year Property	15, 35, or 45 years

   Half-Year Convention for 3, 5, and 10-Year Property: The first year the property is placed in service you can deduct half the amount of the depreciation that would be allowed for a full year. If you hold the property for the entire recovery period, you can then deduct a half year's depreciation for the year following the end of the recovery period. (Exception: 15-Year Property).

2. Problem: Shelly buys a used machine for $500 and chooses a 5 year alternative recovery period. Find deductions for first and second year. Remember the half year rule in the first year.

   a. Basic rate: 1/No. of years of life or 1/5 = 20%.

   b. Unadjusted basis x basic rate = annual depreciation.

   c. First Year: $500 x 1/5 x 1/2 = $50, which yields a first year depreciation as follows: $500 - $50 = $450 balance.

   d. Second Year: $500 x 1/5 = $100, which yields a second year depreciation as follows: $450 - $100 = $350 balance.

References:

1. Economic Recovery Act of 1981: Income Tax Provisions Affecting Farmers and Ranchers, PNW 218/January 1982, A. Gene Nelson, OSU, Gayle S. Willett, WSU, and Manning Becker, OSU.

2. Farmer's Tax Guide, Publication 225, Rev. Oct. 1981, IRS.

3. Farm Business Management, 2nd Ed., Castle, Becker, Smith, Macmillan Pub. Co., New York, 1972.

Note: If an animal dies, write it off for the remaining depreciable balance.

Explanation of Forms:

Two separate forms will need to be kept for Oregon taxes and for the federal government. Oregon uses the old depreciation methods and since January 1, 1981, the federal government uses ACRS. Both forms are new to the record book. The old method has more columns but is easier to figure, the ACRS form is a federal government form with one modification, for student's share value. It is recommended that students use the most current ACRS form in their record book.

COLUMN	ITEM	EXPLANATION
1	Description of Property	Self explanatory.
2	Date Purchased (Acquired) or Placed in Service	For livestock, immature livestock that is not in service cannot be depreciated or claimed.
3	Cost or Other Basis	Usually use purchase price. For livestock, always use purchase price. Ask the question, "What is the basis?"
4	Salvage Value	Used only for straight-line method prior to January 1, 1981 for federal government and use with Oregon taxes.
5	Balance of Regular Depreciation	Col 3 - Col 4
6	Method of Figuring Depreciation	Straight-Line--SL Declining Balance--DB Double Declining B.--DDB
7	Life & Rate	5 years: 1/5 or 20%
8	Depreciation this Year	For straight-line, Col 5 x Col 7. Also the same for declining balance.
9	Depreciation Prior Years	Keep running total.
10	Depreciable Balance Beginning of Year	Col 5 - Col 9
11	Student's Share Percentage	Write in the percentage.
12	Student's Share of Depreciation this Year	Col 8 x Col 11, write in year in space provided.
13	Depreciable Balance for Beginning of Next Year	Col 10 - Col 8, write in year in space provided.
14 - 19	Project--Student's Share Value of this Year's Depreciation (Col 12)	Transfer figure from Col 12.
	Totals	The total for Student's Share of Depreciation this Year is transferred to the Net Income or Loss Statement to be used in the equation.

Note: This form can be used with the federal tax forms. There are more columns here to help figure more easily.

DEPRECIATION RECORD

Line	Description of Property	Date Purchased (Acquired) or Placed in Service	Cost or Other Basis	Salvage Value (SL prior to 1 Jan 81)	Balance For Regular Depreciation Col 3-Col 4	Method of Figuring Depreciation	Life & Rate Yrs;Fraction	Depreciation This Year For SL-- Col 5xCol 7	Depreciation Prior Years
0	1	2	3	4	5	6	7	8	9
1	Dairy Cow	6/24/79	$400-	$125-	$275-	SL	5 yrs;1/5	$55-	$83-
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
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24									
25									
26									
27									
28									
29									
	TOTALS		$		$			$	

DEPRECIATION RECORD

DAIRY COW

Line	Depreciable Balance Beginning of Year Col 5-Col 9	Student's Share Percentage	Student's Share of Depreciation This Year 19__ Col 8xCol 11	Depreciable Balance For Beginning of Next Year 19__ Col 10-Col 8	Project	Project	Project	Project	Project	Project
					Student's Share Value of This Year's Depreciation Col 12					
0	10	11	12	13	14	15	16	17	18	19
1	$192-	100%	$55-	$137-	$55-	$	$	$	$	$
2										
3										
4										
5										
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TOTALS			$	X	$	$	$	$	$	$

AgII-VII-26

Form **4562** (Rev. September 1981)
Department of the Treasury
Internal Revenue Service

Depreciation

▶ See separate instructions.
▶ Attach this form to your return.

OMB No. 1545-0172
Expires 12/31/82

Name(s) as shown on return: James A. Brown

Identifying number: 579-28-6685

▶ Generally, you must use the Accelerated Cost Recovery System of depreciation (ACRS) for all assets you placed in service after December 31, 1980. Report these assets in Part I, lines 1(a) through 1(f).

▶ You may elect to exclude certain property. Report this property in Part I, line 2.

▶ Use Part II for assets you placed in service before January 1, 1981, and certain other assets for which you cannot use ACRS.

▶ Filers of Schedule C (Form 1040), Schedule E (Form 1040) and Form 4835 should see the instructions for those forms before completing Form 4562.

Part I Assets placed in service after December 31, 1980

A. Class of property	B. Date placed in service	C. Cost or other basis	D. Recovery period	E. Method of figuring depreciation	F. Percentage	G. Reduction this yr	H. Student Share % of Reduction
1 Accelerated Cost Recovery System (ACRS) (See instructions for grouping assets):							
(a) 3-year property							
	1981	21,104	5yrs		15%	3165.60	1/10 = 316.56
(b) 5-year property							
(c) 10-year property							
(d) 15-year public utility property							
(e) 15-year real property—low-income housing							
(f) 15-year real property other than low-income housing							
2 Property subject to section 168(e)(2) election (see instructions):							
3 Totals (add amounts in columns C and G) . . .		21,104					

4 Depreciation from Part II, line 3	
5 Total (add column G, lines 3 and 4). Enter this amount on the depreciation expense line (where it applies) of your return	

Explanation of FFA Record Book:

COLUMNS	ITEM	EXPLANATION
1	Item	Write in specific item, e.g. dairy cow
2	Birthdate/ Date Acquired	Day, Month
3	Total Cost	Purchase (or adjusted) price
4	Salvage Value	Price of trade-in or resale value after its use or price when sold. Omit if using declining balance methods.
5	Total Cost Less Salvage Value	Column 3 - Column 4 = Total Cost
6	Student Share Percentage	Write %, e.g. 20%
7	Beginning of Year Student Value	Column 5 x Column 6, $
8	Method of Depreciation	Write in life under "Method of Depreciation" Straight-Line--10 SL 150% Declining Balance--8 DB 200% Declining Balance--6 DDB
9	Depreciation This Year	See methods to compute depreciation, $
10	End of Year Student Value	Column 6 x Column 9 = remaining or depreciable value

DEPRECIABLE ASSETS

DEPRECIABLE ASSETS LEDGER

(Depreciation Schedule)
(Purchased Breeding Livestock, Trees, Vines, Perennial Crops, Equipment, Buildings, Machinery)

(Student's Share)

Items	Date Acquired	Total Cost	Salvage Value	Total Cost Less Salvage Value	Student Share Percentage	Beginning of Year Student Value	Method of Depreciation/ Life	Depreciation This Year	End of Year Student Value	Horticulture Enterprise		Beef Enterprise		Enterprise	
										Beginning	Ending	Beginning	Ending	Beginning	Ending
1	2	3	4	5	6	7	8	9	10	13	14	15	16	17	18
10' x 20' Greenhouse	1/6/80	$ 2000 -	$ 200 -	$ 1800 -	10%	$ 1800 -	SL/10 yrs	$ 200 -	$ 1600 -	$ 1800 -	1600 -	$	$	$	$
Show Equipment	1/8/80	70 -	10 -	60 -	50%	20 -	SL/10 yrs	3 -	17 -			20 -	17 -		
TOTALS		$	$	$		$		$	$	$	$	$	$	$	$

PARLIAMENTARY PROCEDURE

Instructor's Guide:

1. This unit is designed to further develop the parliamentary procedure skills acquired in Ag I.
2. Students should be given higher level motions than were utilized in Ag I.
3. Instructors should have students review the motions and their uses from the Parliamentary Procedure unit found in Ag I. If an Ag I curriculum is not available, the material may be obtained from Washington State University. (see references).
4. Instructors should make assignments that will lead students into the use of Roberts Rules of Order.
5. Practice sessions should focus on agricultural issues that are controversial enough to offer opposing viewpoints.
6. Instructors should provide students with lists of example motions that are interesting, motivational, and stimulating.

Objectives:

Upon completion of this unit, the student will be able to:

1. Chair parliamentary procedure sessions.
2. Participate as a member of a group, using good parliamentary procedures.
3. Make and debate main motions.
4. Make and debate subsidiary motions.
5. Make and debate appropriate incidental motions.
6. Make priveleged motions.
7. Conduct a business meeting by parliamentary rules.

Student Activities:

1. Review parliamentary procedure from Ag I curriculum.
2. Participate in the discussion of parliamentary rules.
3. Participate in discussion at business meetings and parliamentary practice sessions.
4. Serve as chairman of sessions as often as rotations will permit.
5. Use Roberts Rules of Order for settling questions of parliamentary rules.

References:

1. Parliamentary Procedure Made Easier. Extension Circular 947. ASWSU Activities Center, Washington State University, Pullman, Washington, 99163. 50¢ per copy.
2. Rules of Order and Parliamentary Procedure., Roberts, Henry.

ADVANCED FERROUS WELDING

Instructor's Guide

1. This unit is designed to increase the skill of students that received basic welding instruction previously.
2. For review of basic welding refer to the Oregon Ag I guide.
3. The instructional units and transparency masters were selected from materials available from Texas A & M University and the University of Illinois.
4. The material on TIG welding, MIG welding, and use of the carbon arc torch are available from the University of Illinois for departments that have specialized welding equipment.
5. This unit contains sufficient material for instructor references, student handouts and classroom use.
6. Welding instruction should be directed toward "hands on" learning, supported by instructor demonstrations and related study of the technical material provided in this guide.

Objectives

Upon completion of this unit, the students will be able to:

1. Observe the safety rules of arc welding.
2. Define terms associated with welding and welding process.
3. Describe the common arc welding processes such as shielded arc, MIG, TIG, hardsurfing, etc.
4. Understand AWS classifications of welding electrodes.
5. Weld in flat, horizontal, vertical, and overhead positions.
6. Pierce hole with arc welder.
7. Apply hardsurfacing materials to a metal surface.
8. Operate a MIG welder. (Optional unit)
9. Observe the safety procedures in handling oxy-acetylene welding equipment.
10. Describe the common processes in oxy-acetylene welding such as cutting, brazing, mild steel welding.
11. Perform oxy-acetylene welding in flat, horizontal, vertical, and overhead positions.
12. Light blow pipe and adjust flame.
13. Select correct tips for welding jobs.
14. Clean tips properly.
15. Bevel and prepare steel for welding.
16. Weld mild steel by fusion.
17. Bronze weld steel together.
18. Cut steel with oxy-acetylene equipment.
19. Apply hard facing material.

Student Activities

1. Read objectives.
2. Read information sheets provided by instructor.
3. Observe demonstrations by instructor.
4. Complete welds assigned by the instructor.
5. Take unit exams.

Teaching Aids

1. Objectives.
2. Information handouts.
3. Transparency masters located at the end of each unit.
4. A synopsis of Oregon Safety Code, Chapter 17, "Gas and Electric Welding" is provided following this page.

References

1. Metals and Welding, Hoerner and Anderson, Hobar Publication.

SYNOPSIS

Oregon Safety Code

Chapter 17

Gas and Electric Welding

(Chapter 17 is a small, 73 page, bulletin)

To obtain free copies of these rules, address:

Workmen's Compensation Board
Accident Prevention Division
Room 204, Labor and Industries Building
Salem, OR 97310

FIRE PREVENTION AND PROTECTION

17-2-3 Welding operations shall not be permitted in rooms containing flammable vapors, or on closed containers that have held flammable gases or liquids.

17-2-15 No torch or arc shall be applied to any container until the vessel has been freed of all flammable or toxic gases. Small punctured drums, or containers of not more than 60 gallons capacity, may be freed of volatile fumes by draining and flushing and by injecting live steam into the container for not less than 3 hours.

HEALTH PROTECTION AND VENTILATION

17-3-2 Local exhaust systems or general ventilating systems shall be provided to keep the amount of toxic fumes, gases, or dusts below the threshold limit value.

a. Such ventilation shall be at the minimum rate of 2000 cubic feet per minute per welder, except where local exhaust hoods and booths are used.

b. Local exhast systems (hoods and booths) shall maintain a minimum linear air flow of 100 feet per minute at the point where a welding fume is generated.

17-3-3 Welding or cutting operations on zinc coated materials in confined spaces require "Airline Respirator" or "Local Exhaust Ventilation".

17-3-8 Brazing filler metals contain cadmium and/or zinc and are used only with adequate ventilation such as fume collectors, exhaust ventilations, or air-supplied respirators.

17-3-19 Oxygen shall never be used for ventilation.

PERSONAL PROTECTION

17-4-3 Means for sterilizing and maintaining all necessary protective equipment shall be provided.

17-4-4 Protective equipment which contacts the skin shall not be transferred from one employee to another without being sterilized.

17-4-10 Booths and screens shall permit circulation of air at floor level.

17-4-30 Guide for selecting proper shade numbers for lenses:

Welding Operation	Shade No.
Shielded metal-arc (stick welding) 1/16, 3/32, 1/8 & 5/32 inch electrodes	10
Gas-shielded arc welding (non-ferrous "MIG" & "TIG") 1/16, 3/32, 1/8 & 5/32 inch electrodes	11
Gas-sheilded arc welding (ferrous "MIG" & "TIG") 1/16, 3/32, 1/8 & 5/32 inch electrodes	12
Sheilded metal-arc (stick welding)	
3/16, 7/32 & 1/4 inch electrodes	12
5/16, & 3/8 inch electrodes	14
Atomic hydrogen welding	10-14
Carbon arc welding	14
Soldering	2
Torch blazing	3 or 4
Light cutting (up to 1 inch)	3 or 4
Medium cutting (1 to 6 inch)	4 or 5
Heavy cutting (6 inches and over)	5 or 6
Gas welding (up to 1/8 inch)	4 or 5
Gas welding (1/8 - 1/2 inch)	5 or 6
Gas welding (1/2 inch & over)	6 or 8

17-4-32 Welders wear flameproof gauntlet gloves.

17-4-33 Woolen clothing is preferable to cotton because it is not so readily ignited.

17-4-34 Cotton clothing should be treated to reduce its flammability.

17-4-35 No grease or oil on clothing.

17-4-36 Easily ignited, highly flammable clothing, such as synthetic materials (Acetates) shall not be worn.

17-4-37 No cuffs and button collars, sleeves and pockets.

17-4-41 Caps and shoulder covers made of leather shall be worn for overhead welding and cuffing operations.

ARC WELDING

17-5-31 Welding operators shall be instructed on avoiding electric shock.

17-5-36 Coiled welding cable shall be spread out before use to avoid serious overheating.

17-5-37 Cables with damaged insulation shall be replaced (not taped).

17-5-39 The welder shall not coil or loop welding electrode cable around parts of their bodies.

17-5-40 Workmen assigned to operating or maintaining arc welding equipment shall be acquainted with the requirements of this chapter.

17-5-41 Workmen designated to operate welding equipment shall have been properly instructed and qualified to operate such equipment.

17-5-44 Ground clamps shall be free from spatter on contact surfaces.

Oxygen-Fuel Gas Welding

17-7-3 Acetylene pressure never to exceed 15 psi.

17-7-6 No grease or oil on threads.

17-7-8 Fuel gases shall be called by their proper name and not by the term "gas".

17-7-9 Oxygen shall be called by its proper name and not by the term "air".

17-7-14 Instructions covering equipment and piping systems shall be posted in a conspicuous location where they can be easily read.

17-7-17 Operators shall never put down a torch unless it has been turned off.

17-7-19 In multiple cylinder installations only one key or handle is required for each manifold.

17-7-20 Hammers or wrenches shall not be used to open cylinders (return to supplier).

17-7-23 Before connecting the regulator to the cylinder valve, the valve shall be opened one quarter turn and closed immediately (cracked for cleaning).

17-7-24 Always stand to one side when opening the valve.

17-7-35 Valve protection caps shall always be in place, handtight, except when cylinders are connected for use.

17-7-60 Cylinders shall not be moved by dragging or sliding. They may be moved by tilting and rolling them on their bottom edge.

17-7-65 & 66 Acetylene storage inside a building shall be limited to 2000 cubic feet. Acetylene storage inside a building in excess of 2000 cubic feet will have a separate room or shall be kept outside of the building.

17-7-70 Acetylene cylinders will be stored valve end up.

17-7-73 a. Oxygen cylinders shall not be stored near highly combustible material, especially oil and grease; or near reserve stocks of carbide and acetylene or other fuel-gas cylinders.

b. Oxygen cylinders in storage shall be separated from fuel-gas cylinders or combustible materials a minimum distance of 20 feet or by a non-combustible barrier at least 5 feet high having a fire-resistance rating of at least one-half hour.

Connections - Regulators - Valves

17-8-2 An acetylene valve shall not be open more than 3/4 turn.

17-8-3 Where a special wrench is required for opening and closing acetylene valves it shall be left in position.

17-8-20 Approved protective equipment shall be installed in fuel-gas piping to prevent:

a. Backflow of oxygen into fuel-gas supply system.

b. Passage of a flash back into the fuel-gas supply system.

c. Excessive back pressure of oxygen in fuel-gas supply system.

17-8-23 The pressure-relief device shall be located on the downstream of the backflow and flashback protection devices.

17-8-29 A check valve, pressure regulator, hydraulic seal, or combination of these devices shall be provided at each station outlet.

17-8-72 Cylinders shall be located and secured so that they cannot be knocked over.

MANIFOLDING

17-9-2 Cylinder manifolds shall be installed under the supervision of someone familiar with proper practices.

17-9-5 Fuel-gas cylinders connected to one manifold having an aggregate capacity exceeding 3000 cubic feet shall be located outdoors, or in a separate building or room.

17-9-9 Oxygen manifolds shall be separated from fuel-gas cylinders or combustible materials a minimum distance of 20 feet or by a noncombustible barrier at least 5 feet high having a fire-resistance rating of at least one-half hour.

17-9-14 If a manifold with less than 3000 cubic feet aggregated capacity is inside a building having other occupancy (school shops), the manifold shall be located in a separate room of noncombustible construction having a fire-resistance rating of at least one-half hour or in an area with no combustible material within 20 feet of the oxygen manifold.

AGRICULTURAL MECHANICS

Topic 1: Arc Welding

1. General Information

   a. Arc welding dates back to the latter part of the nineteenth century when experimenters discovered that the arc between two carbon electrodes could be used to melt most metals. The arc, struck between the carbon electrode and the metal, heats the metal to its melting point, then the electrode is removed to break the arc and let the metal solidify. This flame (arc) of intense heat is generated as the electric current passes through a highly resistant air gap. The air gap is the space between the lower tip of the electrode and the base metal. The amount of heat generated is approximately 11,000° in the arc.

   b. Arc welding may be defined as the process of fusing two or more pieces of metal together by using the heat produced from an electric arc welding machine. Another way the term may be used - metals are fused together by an electric arc generated between an electrode and base metals

   c. Shielded metal - Arc welding, is another term used to identify the arc welding process. The coat (flux) on the electrode produces a gas which shields the arc from the atmosphere as the electrode melts. This gas generated by the electrode flux as it melts protects the molten metal from oxidation as it solidifies.

   d. The advantages of arc welding equipment in the agricultural mechanics shop are:

      (1) Scrap metal can be used to make and repair many useful items for home and farm use.
      (2) Repairs can be made rapidly on farm machinery and equipment, which is good insurance during harvest time.
      (3) Major cracks or breaks can be repaired on machinery and equipment before they cause a major repair problem.
      (4) Metal repair and construction jobs may be accomplished more economically with an arc welder than with other types of metal repair and construction equipment.
      (5) An arc welder can be used for jobs that require cutting, piercing, gouging, and beveling metal.

2. Types of Arc Welding Machines

Transparencies Nos. 1, 2, and 3

   a. An AC (alternating current) welder is the most common type for general agriculture use. It ranges in size from 180 to 225 ampheres and performs best where the power supply is between 220 and 240 volts.

      (1) Advantages of using 180 to 225 amp AC welding machine are:

         (a) They are large enough to handle most welding jobs.
         (b) The initial and maintenance costs are lower than a welding machine above 225 ampheres.

(c) A 180 amphere AC welder has a "limited input" of no more than 37.5 ampheres on a 230 volt single-phase circuit.

(d) The 225 amphere welder, being somewhat larger, can handle electrodes one size larger than the 180 amphere welder, and on some jobs the welding can be accomplished somewhat faster. Arc blow is not as great in an AC as a DC machine.

b. DC (direct current) welders are generator-type welding machines that are powered by electrode motors, gasoline engines, or other power sources.

(1) Advantages of using DC welders are:

(a) Portable models, powered by engines, can be mounted on trucks or trailers and taken to the work.

(b) Electric power is not necessary for a gasoline powered welder; therefore, they can be used as mobile units for repair work in industry.

(c) More flexibility in welding process, and can be used in a greater variety of applications (i.e. using E7018 electrode for welding medium and high carbon steels).

(2) DC welders produce direct current of both straight (negative) and reverse (positive) polarity. Polarity is the direction in which the current flows across the arc.

(a) Straight polarity is when the electrode is negative and the work is positive.

(b) When the electrode is positive and the work is negative the adjustment is called reverse polarity.

(c) Cast iron, thin metal, aluminum, and bronze is welded with a reverse polarity adjustment. Mild steel is welded with a straight polarity adjustment.

c. AC/DC welders are essentially welders equipped with a rectifier (an electronic device to convert AC to DC). If the rectifier is not operating, the welder is an AC type.

(1) Advantages of AC/DC welding machines are:

(a) With the rectifier operating, direct current is produced.

(b) The noise usually encountered when operating a DC welder is eliminated with a rectifier.

d. Tig (tungsten inert gas) welding units consist of an electric power unit; pressure reducing regulator; torch or electrode holder containing tungsten electrode, nozzle, and gas passages; torch cable; welding cable; water and gas hoses; and gas supply unit. The Tig process is either helium or argon. Gas is measured and purchased by the cubic foot.

(1) Advantages of a Tig welding unit are:

(a) Welds are free of corrosive residue. This is due mainly to no flux being used. There is no contamination of oxygen and nitrogen due to the inert gas keeping air away.

(b) The weld is usually stronger and freer of corrosion than in other forms of welding. The inert gas will not combine with elements that cause the metal to be impure.

(c) The weld is free of fumes and slag. This makes it easy to observe the process while welding in any position.

(d) Stresses are reduced due to the heat concentration in a small area, so there is little distortion near the weld.

(e) There is no splatter in this process, which means that no metal is transferred across the arc.

(f) Almost all metals and alloys can be welded by this process. Aluminum, magnesium alloys, stainless steel, copper, plain carbon steel, nickel, and hardfacing alloys welded to steel are all welded by the Tig process.

(2) The nonconsumable tungsten electrode forms the arc to fuse the base metal with or without the use of a filler rod. Tig welding units can be either AC or DC powered. This type of arc welding is used extensively to weld aluminum and stainless steel.

e. Mig (metallic inert gas) welders are an extension of Tig welders. These types of welders are different from Tig units in that a consumable electrode is used. The electrode is in the form of a thin wire which is usually fed through the torch automatically. Mig units are made up of a welding machine, wire drive and wheel, gas supply, contractor, gun, hoses, current cable (wire), and control unit for wire drive, current, gas flow, and cooling water in part of the unit.

(1) Advantages of using a Mig welding unit are:

(a) The Mig welder is used in industry as an automatic welder (gun is placed in a variable speed carriage).

(b) Welds can be made by using an electrode with a flux core in the gun.

(c) Other Mig welding advantages are listed under the advantages of the Tig welding unit. However, there is a slag cover on the weld when using a flux cored wire.

(2) Mig welders may be operated by hand. This operation is a semiautomatic system of welding.

f. Other types of arc welding processes include laser welding, submerged arc welding, cybertig welding, and electroslag welding. The most commonly used type of arc welding is

still the use of a coated electrode (stick electrode) that shields the weld puddle from the air. Burning chemical compounds form a blanket of smoke and gas around and over the molten pool of metal.

3. Selecting a Welder and Other Equipment

   a. Select a welder that is made by a reliable manufacturer and sold by a reliable dealer.

   b. The dealer should have an adequate supply of protective equipment, operational information, electrodes. Dealers should also be in the position to give prompt service when it is needed.

   c. When comparing the prices of welders of equal capacity, check the guarantee on the different machines.

   d. The power supply is the most important element in any type of welding machine. Adequate voltage must be available in order to strike an arc and make a good weld; therefore, the power supplier should be contacted regarding the availability of 230 volt service.

   e. The arc welder is usually equipped with ground and electrode cables. The cables are fitted with a ground clamp and an electrode holder.

   f. Additional welding is as follows:

      (1) Welding helmet equipped with the proper colored glass.
      (2) Blacksmith tongs and pliers.
      (3) Gauntlet type leather gloves.
      (4) Chipping hammer and a wire bush.
      (5) Welding table and a stool or metal chair.
      (6) C-clamps, clear goggles, water can, and soapstone.
      (7) Welding booth or portable screen.
      (8) Power grinder.

4. Installation and Maintenance

   a. Have a competent electrician install the welder according to the requirements of the National Safety Code. The welder must be grounded.

   b. The welder should be located in a dry, well ventilated, well lighted place, yet it should be accessible for use on all jobs.

   c. If the cables become frayed, repair them by cutting out the freyed part and reattaching the fittings; never leave the metal cables exposed. Keep all connections on the cables and welder tight.

   d. Blow out dust and dirt from the transformer coils of the welder monthly. Dirty coils cause excessive heating.

   e. Periodically, clean and inspect contractors, switches, relays, and connections, and replace worn or broken parts.

5. Safety Practices to Observe When Using the Arc Welder

a. Most injuries that are caused by arc welding machines can be prevented if certain precautions are observed. The five major safety items that are of utmost importance are:

(1) Electrical Shock - The open circuit voltage of an AC welder may not exceed 90 volts, but the electrode holder and welder should always be handled with care. Some of the safety practices include:

(a) Be sure the welder is properly grounded.
(b) Secure services of a competent electrician when making an electrical installation.
(c) Do not run machinery over welding cables.
(d) Do not stand on wet surfaces when welding.
(e) Use only electrode holders that are well insulated.
(f) Wear leather gloves.

(2) Radiant Energy - The arc welding process gives off the same ultra-violet rays as those transmitted by sunlight. The rays given off by the welder are more concentrated than the sun rays. The safety practices to observe are:

(a) Cover the face and eyes with a sheild or helmet before striking an arc.
(b) Give a warning to all people standing by before striking an arc.
(c) Examine the helmet for cracks that would let in light.
(d) Wear protective clothing such as high top shoes, long sleeves, buttoned collars, cuffless pants, and welding gloves. Burns can be caused by wearing improper clothes.

(3) Gases and Fumes - Gases and fumes may become a safety problem when welding area is not well ventilated. A fan must be used to reduce fumes when welding galvanized metal (the fumes from the oxidized zinc coating are toxic).

(4) Combustible Materials - Welding enclosed containers which have held combustible materials is very dangerous. There is a definite danger of an explosion unless all precautions are observed.

b. Miscellaneous safety rules

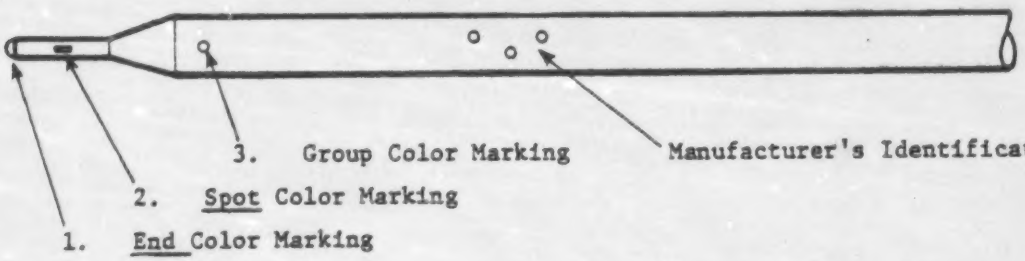
(1) Do not lay an electrode holder on the welding table.
(2) Do not stand on metal that is grounded.
(3) Keep work area clean to avoid falling or slipping.
(4) Keep tools and equipment in a safe place so they will not fall on the operator.
(5) Do not hold the electrode holder between the knees or under the arm.
(6) If the electrode sticks and cannot be twisted free, cut off switch to the machine; allow electrode to cool and break it loose with pliers.

(7) Do not cool electrode holder in water.
(8) Never rub the eyes if foreign paticles get in them.

6. Electrode Classification and Selection

All major manufacturers of welding electrodes use the American Welding Society (AWS) and the American Society for Testing Materials (ASTM) code of specifications. There are several manufacturers of electrodes, and each company makes basically the same quality which is established by AWS. Most electrode manufacturers have adopted the AWS system of identifying electodes, and that is by numbering each electrode. The National Electrical Manufacturer's Association (NEMA) color code system of identifying electrodes is still used to some extent, but the color coatings or markings should not be confused with trademarks of the manufacturer. Electrodes are classified according to the type of coating, composition of the weld metal, and operating characteristics.

a. Electrodes may be identified by color markings in the following manner:



The meaning of the color code system is explained by NEMA. For example, if the spot color is brown with no end color this means that the electrode is used to weld mild steel and is an E6013 electrode.

b. Identifying some commonly used electrodes by the AWS classification, NEMA color markings, manufacturers numbers and polarity is as follows:

AWS Class	NEMA Color Code	Trade Name and/or number	Polarity
E6010	None	Lincoln 5	DC*** RP
E6011	*E-None**S-Blue	Hobart 335A	DC AC RP
E6012	E-None S-White	Marquette 120	DC AC SP
E6013	E-None S-Brown	Airco 90	DC AC SP
E6014	E-Black S-None	A.O. Smith SW15	DC AC SP
E6018	E-Black S-Orange G-Green	Hobart LH718	DC AC RP
E6013	E-None S-Brown	Lincoln 37	DC AC SP
E6011	E-None S-Blue	Marquette 130	DC AC RP

*E - End color marking
**S - Spot color marking
***RP - Reverse Polarity
SP - Straight Polarity

The meaning of the AWS class number (E6013) is:

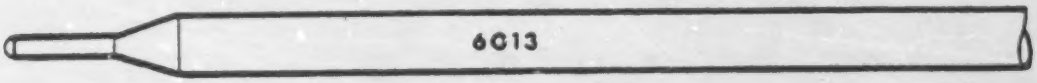
E - The electrode for electric arc welding.

60 - The tensile strength of the electrode metal (psi). Example: 60 x 1,000 or 60,000 pounds per square inch.

1 - Weld flat, horizontal, vertical, and overhead. If the third number is a 2, it can be used for flat and horizontal welding, but 3 means flat only.

3 - May mean the chemical analysis of the flux; the polarity of the electrode, AC or DC rating or the penetrating capacity of the electrode. The E6011 will penetrate deeper and have less slag than an E6014 electrode.

c. The size of the electrode to use depends on the job to be performed. The actual size of an electrode is determined by the bare end of the rod.



Specifications for an E6013 Electrode

Standard Size Diameter of core wire	Approximate No. of Electrodes per pound	Standard Length	Amperage Rating
1/16 inch	53	18"	20 - 40
3/32 inch	36	12"	30 - 80
1/8 inch	17	14"	70 - 120
5/32 inch	11	14"	120 - 170
3/16 inch	8	14"	140 - 240

d. One of the main purposes of the flux on an electrode is to furnish a gaseous smoke screen to envelop the arc and protect the molten metal from harmful atmospheric effects of nitrogen and oxygen. The flux coating that does not burn to form the gaseous shield mixes with the metal impurities and settles as slag on the welded metal. The slag may also be considered beneficial to certain types of welds because it holds heat and keeps the weld from cooling too fast.

e. The three main types of electrodes are:

(1) Coated Electrode - Coated electrodes are used mainly to weld steel. The core is usually steel. If this type of electrode is properly selected, it will have the same or similar properties as the base metal.

(2) Bare Electrode - The bare rod usually requires an excessive amount of heat (10,000 degrees F.) as it passes across the arc. This type of electrode or rod is low-carbon, but it is exposed to oxygen and nitrogen and the oxides and nitrides make the weld hard and brittle. Other characteristics of the electrode include being sensitive to voltage change, electrode angle, and smoke free, which makes the weld visible at all times.

(3) Carbon Electrode - This type of electrode melts very slowly and does not become part of the finish weld but does supply a stable arc. The electrode is used for special types of welding where a heat source is needed and a filler rod is used to complete the weld.

f. Electrodes may be classed according to the following special uses:

(1) Mild steel (2) Cast iron

(3) Alloys (4) Hard surface

(5) High - carbon steel

Electrode No.	
E6010	Used mainly to weld mild steel with a DCRP unit. The penetration is deep.
E6011	Used the same as E6010 except with an AC unit.
E6012	Use with either AC or DC units. The penetration is medium.
E6013	Used on AC, DCRP or DCSP units. Medium penetration, medium slag, and quiet arc. A good general purpose electrode.
E6020	Used on AC, DCSP, or DCRP machines. The rod has a heavy coating which is high in iron oxide. It is used to weld machine bases and other heavy metal. High amperage gives deep penetration.
E7018	DCRP is best (if an AC machine has 85+ OCV (Open Circuit Voltage) the chances of successfully starting E7018 rod are increased). This electrode is used on high carbon steel which is considered difficult to weld. It has an iron powder coating.

E7024	Iron oxide powder flux which requires high amperage setting. It yields very smooth welds with good penetration.

Numbers E6010 and E6011 can be used with ease in the vertical and overhead positions because they solidify rapidly.

7. Preparing Metal for Welding

Transparency No. 4

a. Metal should be thoroughly cleaned before it is welded. Stronger, cleaner, and better-appearing welds are made in less time if the metal is properly prepared. E6011 electrodes are one of the few electrodes capable of penetrating unprepared metal. At times preparation is impossible; however, when and where possible, clean and prepare the metal for welding.

b. An additional 20 ampheres is required to weld rusty or greasy metal than is required to weld clean metal.

c. Metal may be cleaned by brushing, filing, grinding, and scraping. Grinding is considered the best way to clean metal.

d. Proper preparation of the stock is as follows:

(1) If the pieces of metal are less than 1/4 inch thick, clean the metal only.

(2) Stock that is more than 1/4 inch thick should be beveled at a 30-degree angle. The two pieces of metal placed with the beveled edges together will form a 60-degree angle.

(3) If stock is beveled on one or both sides, the unground surface remaining should be 1/16 to 3/32 of an inch thick.

(4) Metal pieces that are over 1/4 inch thick should be spaced 1/32 to 1/16 inch apart before welding.

8. Regulating the Current and Correct Welding Positions

Transparency No. 5

a. After the electrode is selected, the welding machine amperage should be set to get a good penetration with a minimum of spatter. The amperage setting is determined by thickness of metal, size of electrode, speed of travel, and position of weld.

b. If the amperage is too high, the bead will be flat and porous; and the edges will be spattered. If the amperage is too low, the metal will pile up making a high, narrow bead. A bead, welded with low amperage, will not have the proper penetration.

9. Types of Welds and Weld Joints

Transparency Nos. 6 and 7

a. The two types of joints most commonly used on arc welding are the butt and fillet welds. The following numbers (1) and (2) are butt welds and numbers (3), (4) and (5) are fillet welds:

(1) Square Joints are unbeveled if the metal is less than 1/4 inch thick, and the two pieces are spaced about 1/2 their thickness apart to permit good penetration.

(2) Single Beveled and Double-Beveled Joints insure penetration and fusion of the metals. The pieces are also spaced apart for welding purposes. Metal that is more than 1/4 inch is usually beveled.

(3) Tee Joints are made by placing two pieces of metal together to form a T. The two pieces are welded together with one or more passes of a fillet weld.

(4) Lap Joints one piece of metal is placed over the other, and they are joined together by welding the ends.

(5) Corner Joints the corners, forming a groove with a 90-degree angle, are placed together at right angles.

10. Steps used When Making Butt and Fillet Welds

Transparency No. 8

a. Butt welds in the flat position are most commonly used. Most broken parts of machinery can be replaced by a butt weld. Butt welding steps in the flat position are:

(1) Place two pieces of metal side by side leaving a 1/16 inch space between the two pieces for thin metal and 1/8 inch space for heavy metal.

(2) Tack weld each end of the prepared pieces. Tacking is to prevent warping while the metal is being welded.

(3) If the metal is beveled, start the pass in the groove on the tack weld. Use a very short arc for the first pass. The electrode lead angle can be as much as 45 degrees.

(4) If an unbeveled metal plate is being welded, it should be tacked and a welding pass made from both sides of the plate. A steel strip may be used if the joint cannot be fitted.

(5) The first (root) bead is made without a weaving motion of the electrode. The future passes are made by a crescent weave, but between each pass the prior bead or weld is cleaned before making the next pass.

(6) If a crescent bead is used, the arc must be hesitated on each motion at the edge of the groove in order to build up the edges of the bead.

(7) On the last pass, a weaving motion must be used on heavy metal to obtain a reinforcing cover over the preceding beads.

Transparency No. 9

b. Fillet welds are used to join two surfaces that meet at right angles. Flat fillet welds are very easy to make if the two pieces of metal to be welded form a "V" in the up position. Fillet welding steps in the flat position are:

(1) Place two pieces of plate metal together forming a "T" (upside down); tack both ends of the pieces to prevent distortion.

(2) The electrode may either be placed in the electrode holder at a 45-degree angle, or the electrode may be held at a 45-degree angle from each side of the plates when making a welding pass. The electrode should also be pointed into the joint with a 15-degree lead.

(3) Move the electrode steadily along the seam at a rate that allows the weld puddle to penetrate each piece of metal. A side-to-side motion is not necessary on the first pass. If a 5/32 inch electrode is used, one inch of weld should be laid for each inch of electrode used.

(4) The second pass is made after cleaning the slag from the bead with a wire brush. The second bead should be laid on the flat surface against the first bead. Slag is removed from the second bead.

(5) The third pass is laid on top of the first pass and against the vertical plate. It also penetrates the edge of the second pass. Slag is removed from the third pass.

(6) If it is necessary to lay additional passes, the forth bead should be laid at the bottom, the fifth and sixth beads should follow to complete the weld.

(7) Welding speed can be increased and undercutting reduced if a "T" joint is welded in a "V" position. The arc should be short and the electrode must be held in the center of the "V" to make a good weld. Weaving may be practiced if more than one bead is laid.

(8) When welding thin metal to heavy metal, the angle of the electrode should be about 60 degrees from the heavier metal.

(9) The bead(s) should be cleaned and checked for uniformity and penetration.

11. Other Position Welding

a. The three different types of position welds are referred to as vertical, horizontal, and overhead. The vertical weld is used more than the other two.

b. The difficulty encountered when making an out-of-position

weld is the control over the molten metal in the puddle. The puddled metal has a tendency to fall from the puddle. General practices to follow when making a position weld are:

(1) Use an amperage setting that will permit the highest current possible for handling the thickness of the metal being welded.

(2) The electrode should be placed in the proper position for the weld.

(3) Strike the arc and hold it shorter than is required for flat position weld.

(4) Begin by moving the electrode slowly until the molten metal will no longer remain in the puddle; increase the speed until a desired build-up of metal is obtained. The metal will solidify before dropping off if the correct speed is used.

(5) Use the proper size and type of electrode. AWS No. E6011 electrode is suited for position welding. Electrodes of smaller diameter are easier to control than large diameter electrodes.

(6) After the bead(s) are laid, they should be cleaned and checked for uniformity, sags, craters, penetration, and width.

Transparency No. 10

c. Vertical Welding - The two most commonly used methods of vertical welding are "vertical-up" and "vertical-down". The steps for making the welds are:

(1) Light metal is easier to weld than heavy metal. For example, in order to get the "feel" of position welding, use metal 1/8 inch thick and an electrode 8 inches long; set the amperage between 60 to 80.

(2) Place the metal plate in a vertical position and secure before starting the weld.

(3) Place the electrode in the electrode holder. Position it at an angle of 60 degrees to the plate and in the path of the weld. The electrode should be perpendicular to the sides of the plate.

(4) Begin welding at the top of the plate with a very short arc. If the electrode sticks to the plate, increase the amperage. If a "burn through" is repeated several times, lower the amperage or increase the speed downward.

(5) When welding vertical-up, place the electrode in the electrode holder so that it may be held at about 90 degrees to the metal in the path of the weld.

(6) Weld thick metal by using one or more side-to-side motion passes.

Transparency No. 11

d. Horizontal Welding - This type of weld is used to butt weld plates or make repairs in the horizontal plane position. The welding steps are:

(1) Secure a plate in a position for running beads in a straight line form left to right.

(2) Place the electrode in the holder so that it can be held at 90 degrees from theplate sides. Lean the top of the electrode slightly toward the area to be welded.

(3) Bevel metal pieces over 1/8 inch thick before welding them together in the horizontal position. Tilt the electrode according to the pass and bevel when welding thick metal.

(4) Adjust the amperage, speed, and length of arc to prevent excessive sagging.

(5) When welding thick metal that has been beveled, more than one bead or a weaving bead should insure a stronger weld.

Transparency No. 12

e. Overhead Welding - Overhead welds are made similar to flat position welds, except they are much more difficult to make than any type of weld. The major difficulties are to maintain a short uniform arc and protect the body from molten metal. The overhead welding steps are:

(1) Secure the metal plate above the head when in the standing position.

(2) Protect the body by wearing protective clothing. (Heavy jacket with long sleeves and tight collar.)

(3) Place the cable on the shoulder and hold the gloves in a position to prevent sparks from entering them.

(4) Place the electrode in the holder to permit the most comfortable position for welding.

(5) Use a 1/8 inch or 5/32 inch rod, and the same amperage setting that is used for vertical welding. If the electrode sticks, increase the amperage.

(6) Weld with a short arc and a moderately fast rate of travel to prevent sagging and undercutting.

(7) Use a weaving pattern on heavy metal. The weaving motion must be somewhat faster than other position welds.

12. Welding Various Kinds of Metals

a. Cast Iron - This metal is very difficult to weld. It expands, contracts, and even crumbles under certain heating conditions. As the metal cools, cracks may appear in or near the welded area. The two types of electrodes for welding cast iron are:

(1) Nickel or copper - core electrodes are used to weld to steel. The major purposesof using these types of electrodes are:

(a) The metals are machinable.
(b) The casting(s) do not require preheating.
(c) The cooling speed does not have to be controlled.
(d) The electrode is more expensive than a steel-core electrode; but in nearly all cases, the cost of the weld is less expensive.

(2) Steel-core electrodes are not recommended for malleable cast iron. Preheating and controlled cooling is necessary if steel-cor electrodes are used. Also, the weld cannot be machined when using this type of electrode.

b. Sheet Metal - Observe the following practices when welding sheet metal:

(1) Use low amperage and weld as rapidly as possible to prevent burning a hole in the metal.

(2) Use an electrode no larger in diameter than the thickness of the metal.

(3) Use a short arc.

c. High Carbon Steel - High carbon steel becomes brittle if it is cooled very rapidly. Welding practices include:

(1) Preheat the metal to a blue color and maintain this color throughout the weld.

(2) Use a mild steel electrode and lower amperage than is used for welding mild steel.

(3) Allow the metal and welded area to cool slowly.

13. Arc Welder Cutting

Transparency No. 13

a. The arc welder is not a metal cutting machine, but metal can be cut, pierced, or gouged if the proper procedure is used. The electric arc can be used to cut steel, cast iron, and many nonferrous metals. More fumes are produced from cutting than welding; therefore, the cutting area should be well ventilated. Fumes from cutting galvanized metals, lead, brass, bronze, and painted metal can be dangerous of inhaled.

b. Some steps to follow in cutting metal include:

(1) Select a mild steel (E6011) electrode 1/8" to 3/16" and use a welding current at 160 to 180 ampheres. Soak the electrode in water for about 10 minutes. An electrode that has lost its coating should not be used.

(2) After arranging a sand pail to catch the molten metal, start the cut at the edge or corner of the base metal. The area to be cut should be extended over the edge of

the welding work table. Use the electrode in a similar manner as a chisel; push the electrode up and down and move it slowly along the line to be cut. The upward stroke arc forces the molten metal out.

(3) To pierce rough holes in metal less than 1/4 inch thick, use the following method:

(a) Strike the arc and hold it in one spot until the metal begins to melt. The electrode should be held at a 90-degree angle to the surface for cutting a straight hole.

(b) Push the electrode down at a rapid rate or as rapidly as possible as the metal continues to melt.

(4) Cutting bevels can be accomplished by using the arc welder but a much neater job is realized when using a grinder or oxyacetylene cutting torch. If it is necessary to use the arc welder for beveling, the following steps may be used:

(a) Lean the electrode in the direction of the bevel. The angle between the electrode and metal should be the same angle as found on the finished bevel.

(b) Hold the cone of the electrode near the metal and move the electrode in the direction of the cut as the metal is blown from its path of travel.

14. Hard Surfacing

Transparency No. 14

a. Hard surfacing, sometimes called hard facing, is the process of applying a layer of wear-resistant metal to the surface or cutting edge of a part to increase its life.

b. Hard surfacing is mainly used to repair worn edges of farm equipment, such as plowshares, cultivator sweeps, harrow spikes, and planter shovels.

c. The steps for hard surfacing are as follows:

(1) Grind the surface free of rust and scale.

(2) Select an abrasive work-hardening electrode and set amperage between 75 and 100 degrees for a 1/8 inch electrode or 130 to 140 degrees for a 5/32 inch electrode.

(3) Apply the hardening metal in even thin layers by using a weaving bead no wider than "1 inch".

(4) Remove slag before laying additional beads.

(5) A certain amount of shaping can be done by grinding, but if there is excessive build-up, shape the metal by heating and forging.

(6) The steps in hard surfacing a plowshare are:

(a) Run the beads from the heavy part toward the point on the underside (ground side) and parallel to the cutting edge.

(b) Lean the electrode at about a 30-degree angle with the burning point in the direction of the plowshare point.

(c) Lay weaving beads side-by-side until the cutting surface is covered. The layer must be smooth.

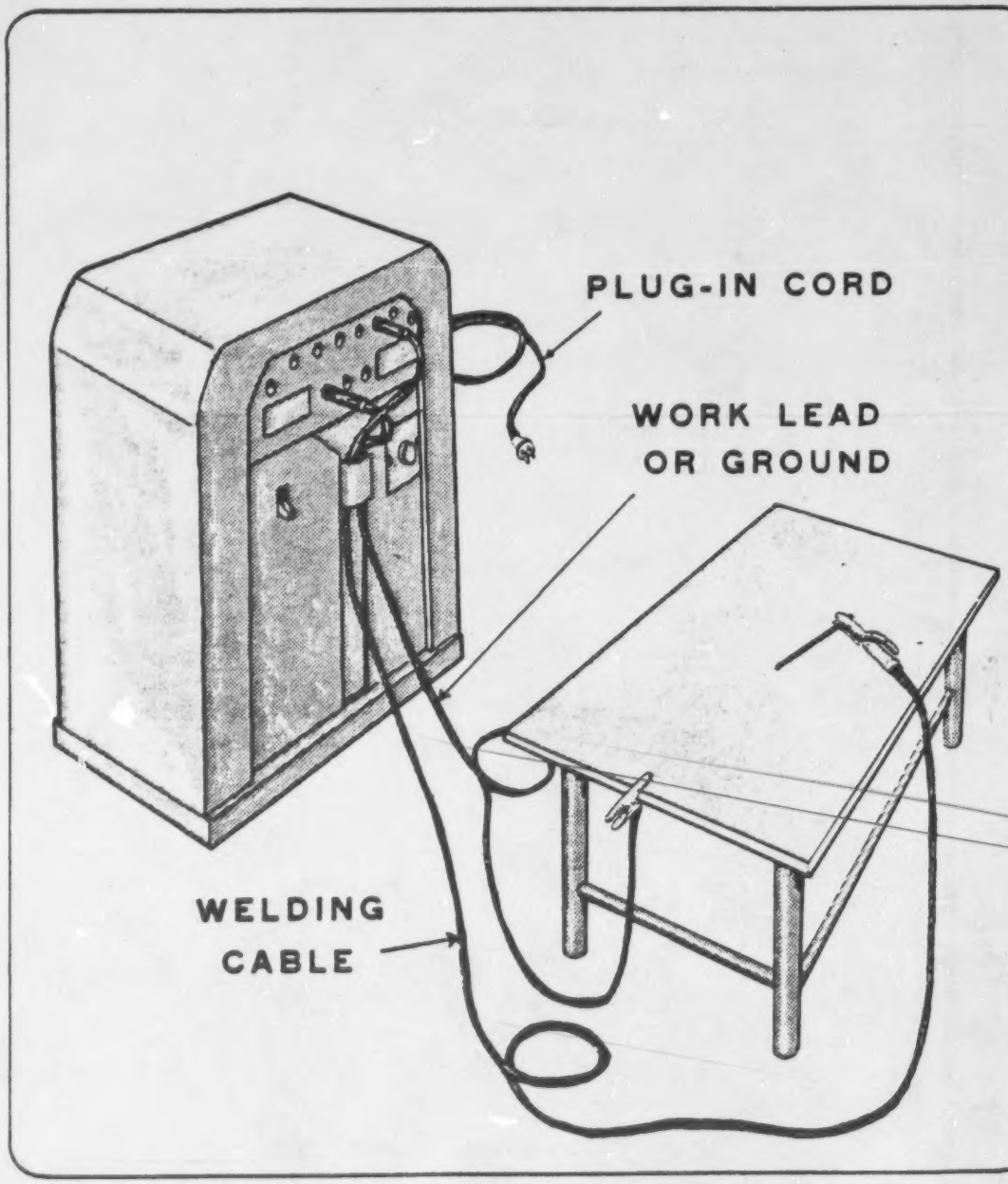
(d) If necessary, peen the deposited weld metal as it cools.

d. The steps for hard surfacing a thin cutting edge are as follows:

(1) Apply hardsurfacing powder in a layer twice as thick as the finished deposit. This powder can be applied dry or as a paste, and it should cover the entire area that needs to be hardened.

(2) Use a carbon arc torch (carbon arc attachment may be used on AC or DC welder) in a circular motion to fuse the powder to the base metal. Carbon arc welding is usually done an a flat surface because the flame cannot be blown into a recessed area.

AC ARC WELDING MACHINE



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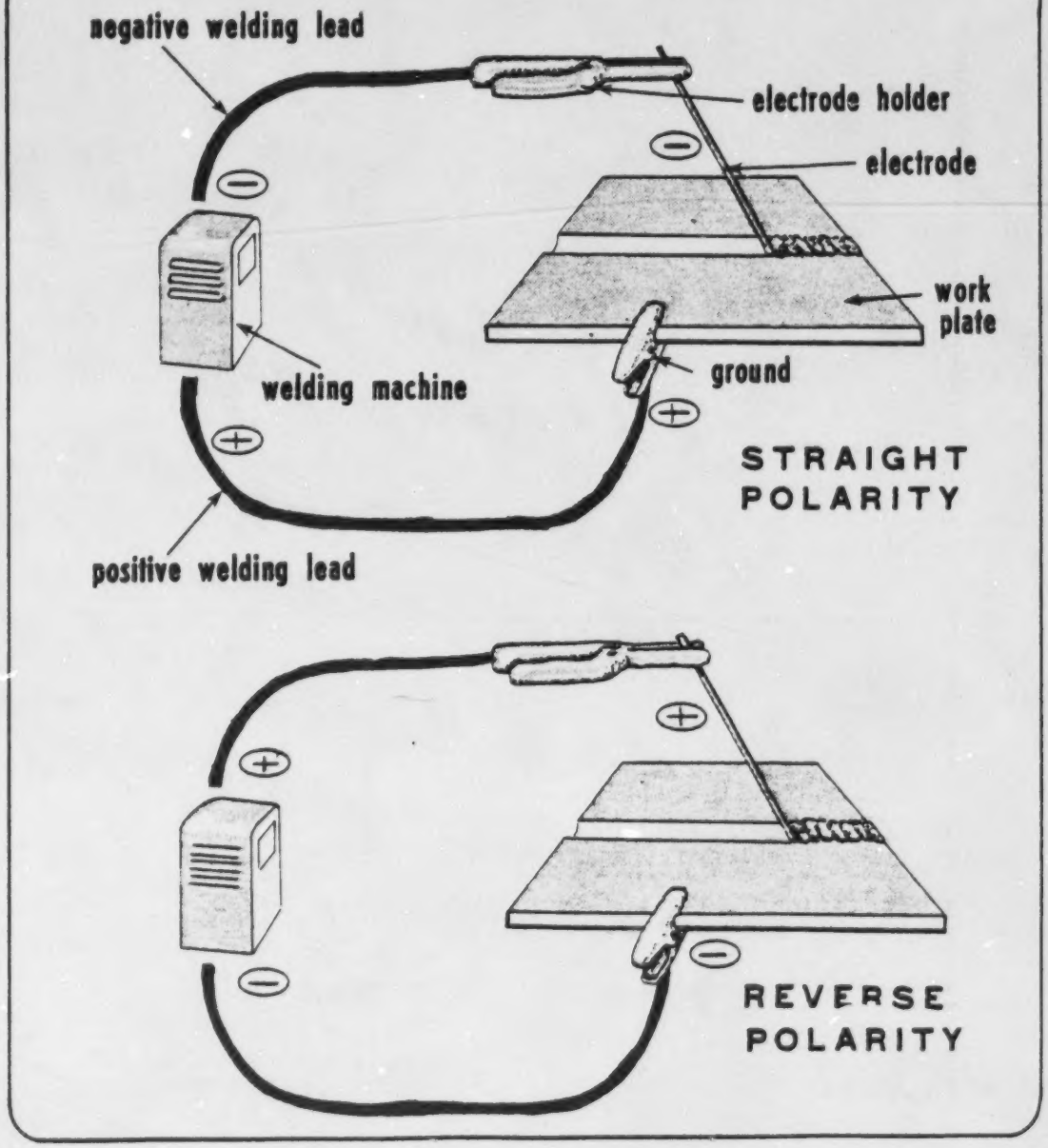
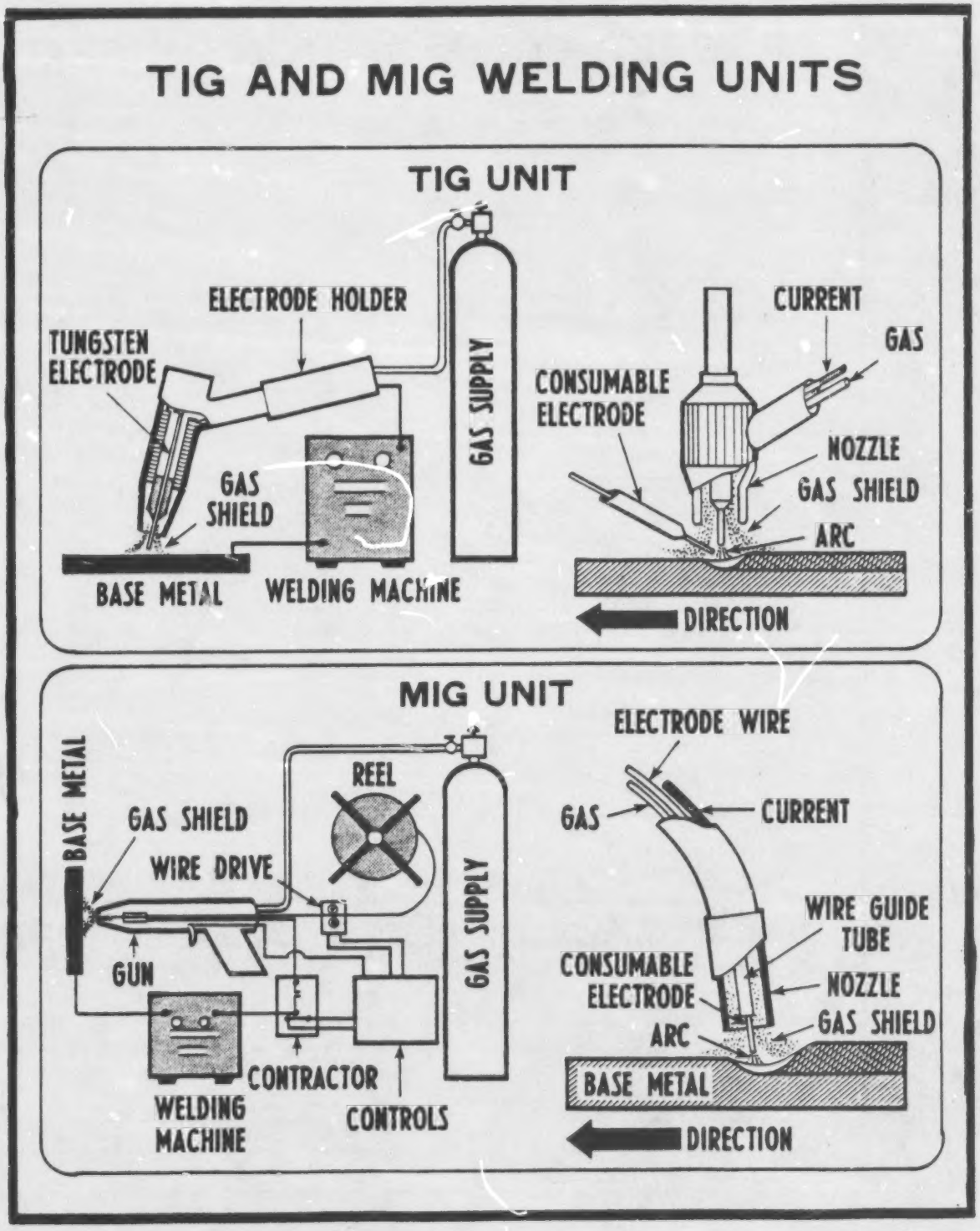
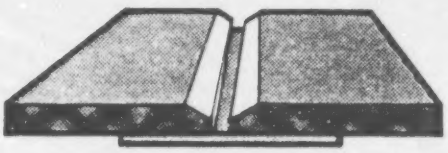
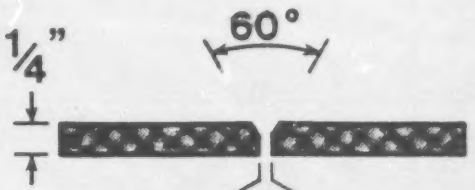



TIG AND MIG WELDING UNITS
TIG UNIT
ELECTRODE HOLDER
TUNGSTEN ELECTRODE
GAS SHIELD
GAS SUPPLY
BASE METAL
WELDING MACHINE
CURRENT
GAS
CONSUMABLE ELECTRODE
NOZZLE
GAS SHIELD
ARC
DIRECTION
MIG UNIT
BASE METAL
GAS SHIELD
WIRE DRIVE
REEL
GAS SUPPLY
GUN
CONTRACTOR CONTROLS
WELDING MACHINE
ELECTRODE WIRE
GAS
CURRENT
WIRE GUIDE TUBE
CONSUMABLE ELECTRODE
NOZZLE
ARC
GAS SHIELD
BASE METAL
DIRECTION

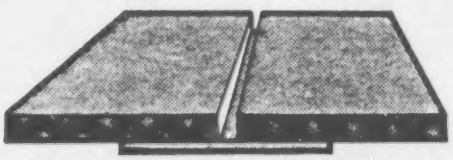
PROPER PREPARATION OF STOCK



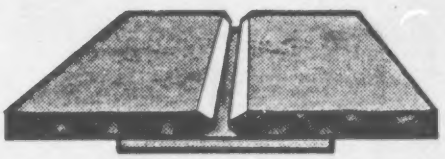
ONE SIDE BEVELED



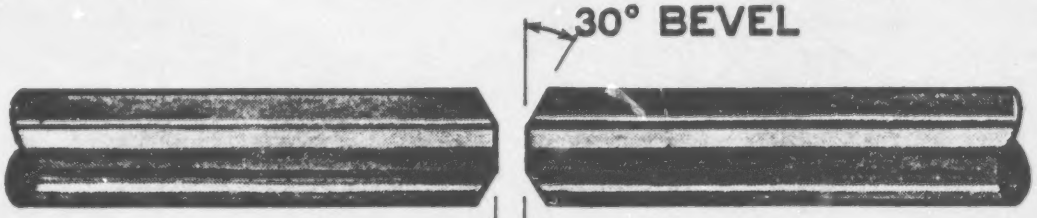
SPACED 3/32" APART



JOINT WITHOUT BEVEL



TWO SIDES BEVELED



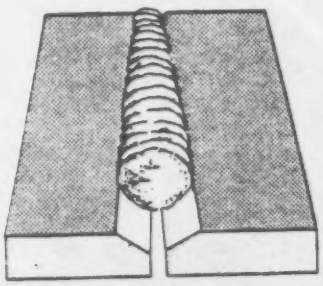
ROUND STOCK BEVELED ON TWO SIDES

ADJUSTING THE CURRENT

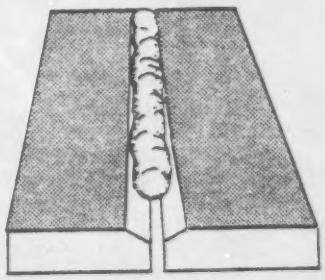
NORMAL BEAD

HIGH BEAD
(low penetration)

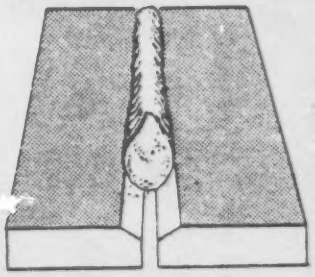
LOW BEAD
(under cutting)



CORRECT AMPERAGE



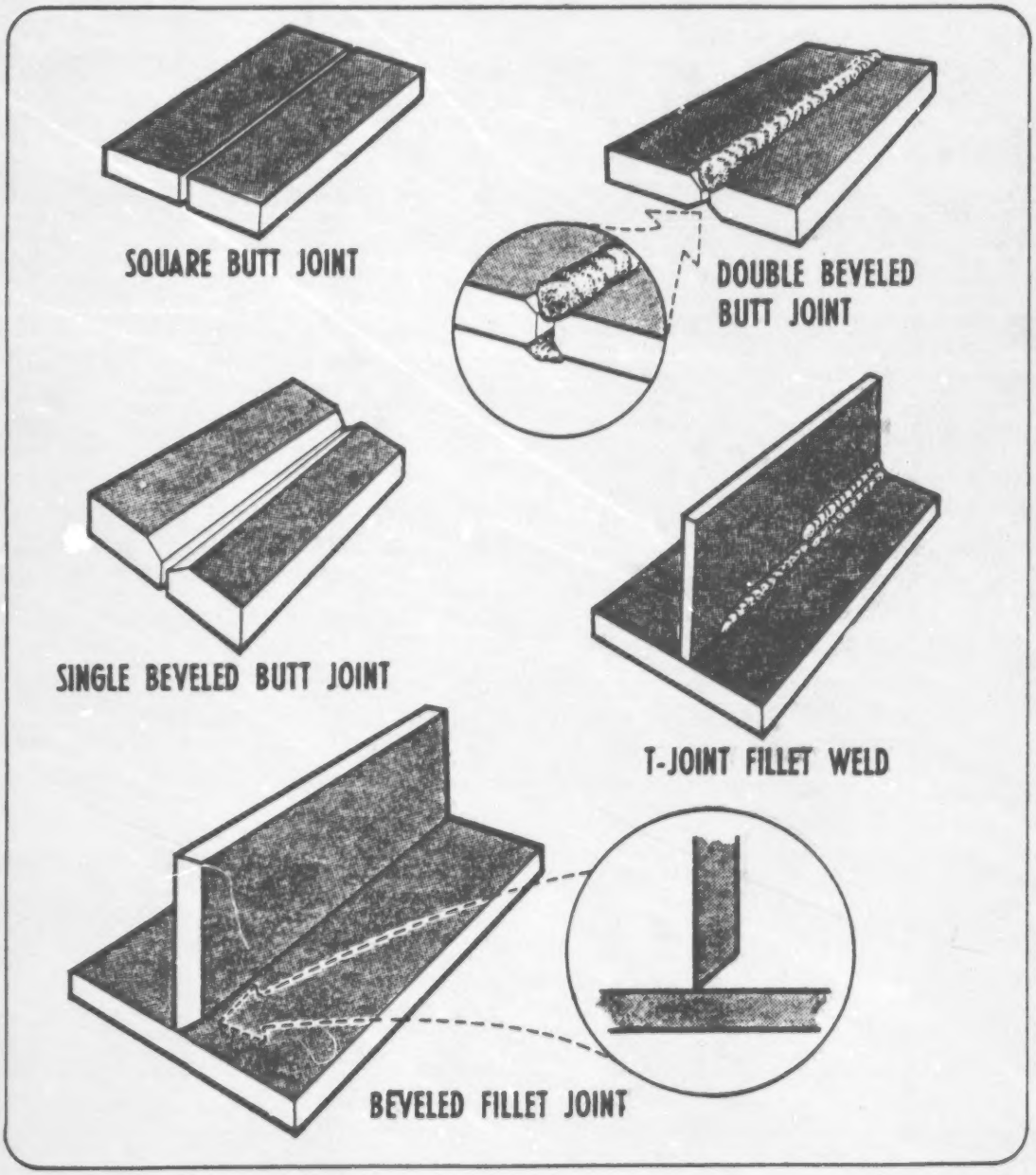
LOW AMPERAGE



HIGH AMPERAGE

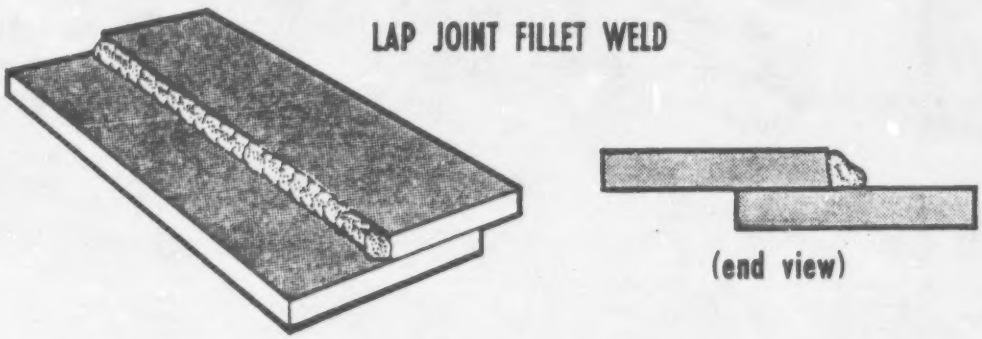
AMPERAGE	ELECTRODE SIZE	METAL THICKNESS
65	3/32"	1/16"
80-100	3/32"	3/32"
80-110	1/8"	1/8"
115-130	5/32"	3/16"
130-150	5/32"	1/4"
140-150	5/32"	5/16"
160-175	5/32"	3/8"
175-200	5/32"	1/2"

TYPES OF WELDS AND JOINTS

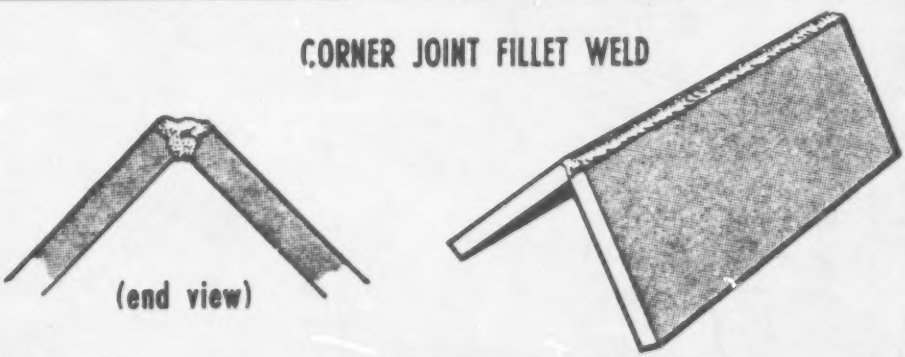


TYPES OF WELDS AND JOINTS

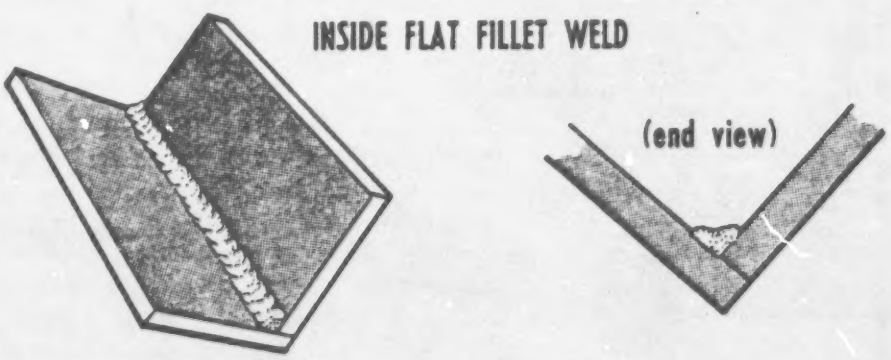
LAP JOINT FILLET WELD



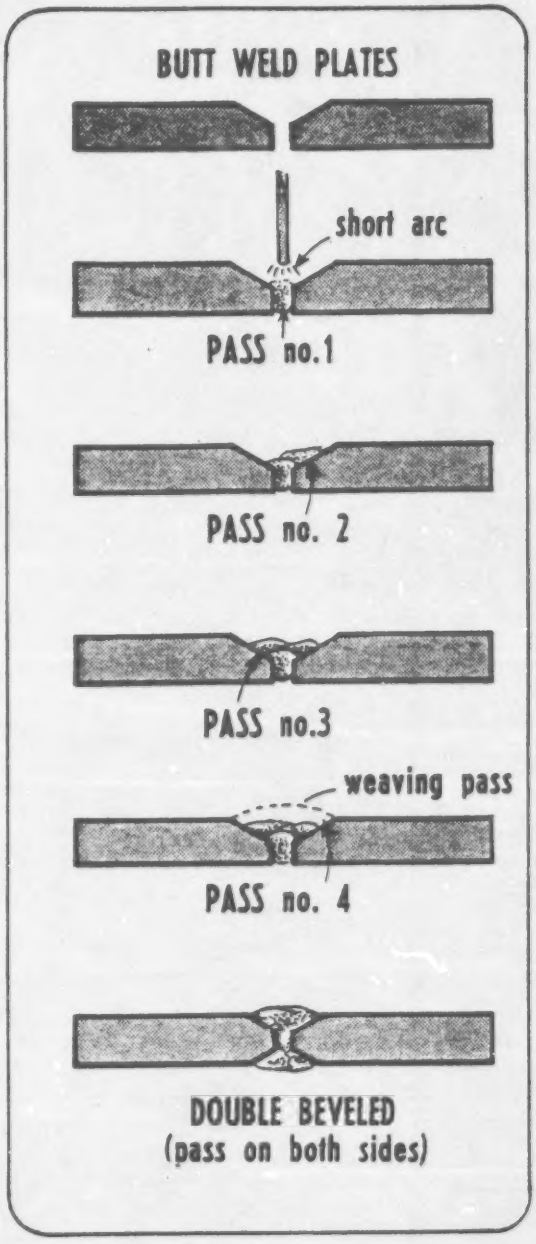
CORNER JOINT FILLET WELD



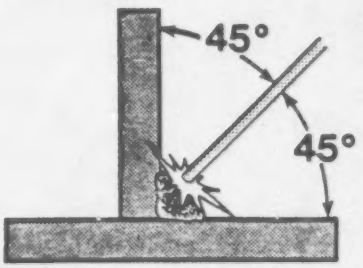
INSIDE FLAT FILLET WELD



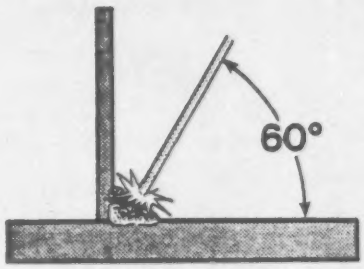
STEPS IN MAKING BUTT WELDS



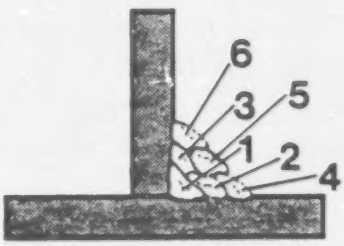
STEPS IN MAKING FILLET WELDS



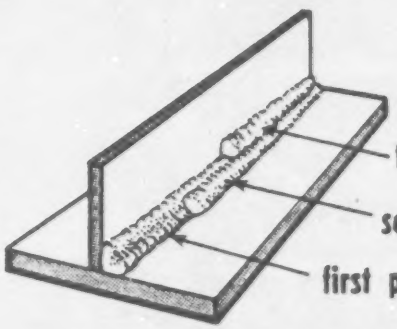
METAL WELDED FORMING "T"



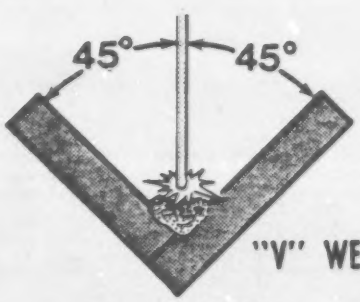
THIN METAL WELDED TO THICK METAL



SIX PASS WELD

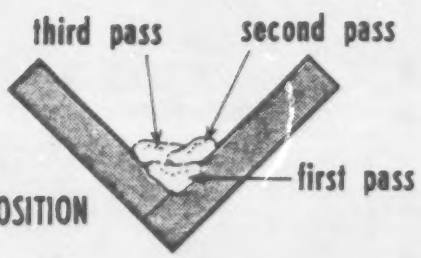


POSITION OF ELECTRODE



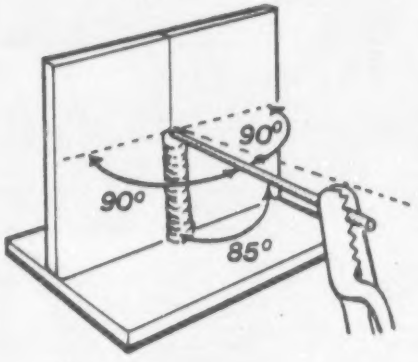
"V" WELD POSITION

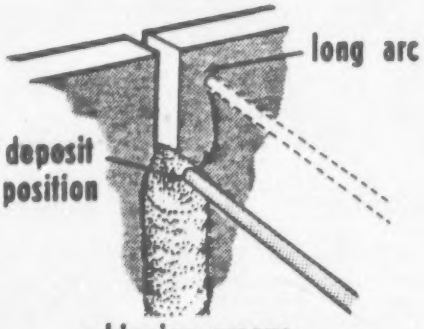
first pass 45°

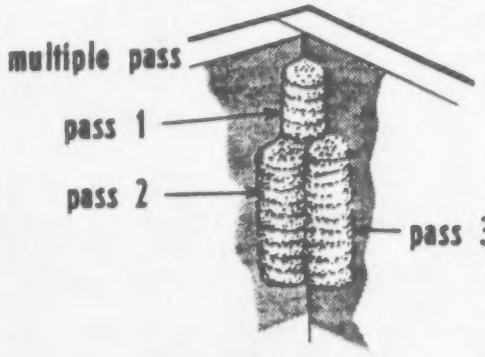


OTHER WELDING POSITIONS

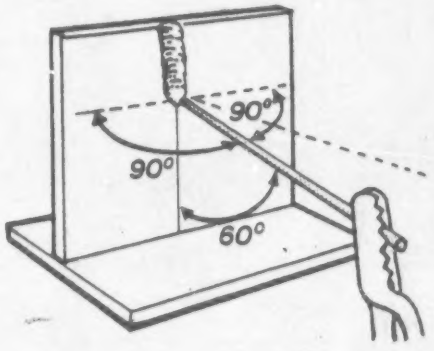
VERTICAL UP

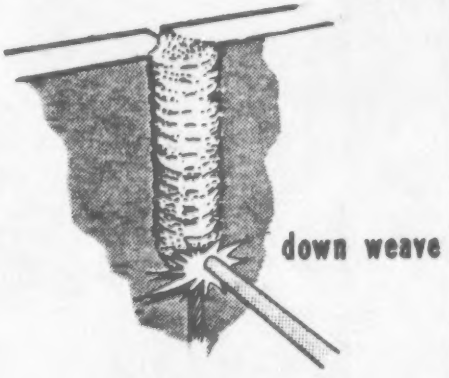


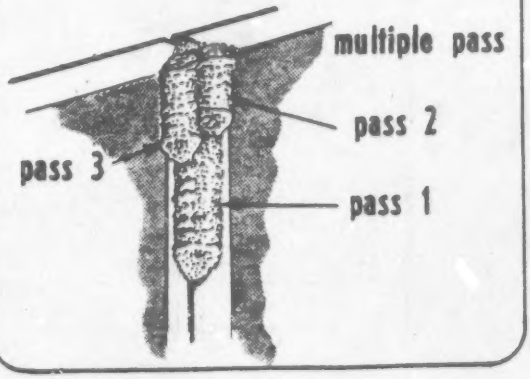




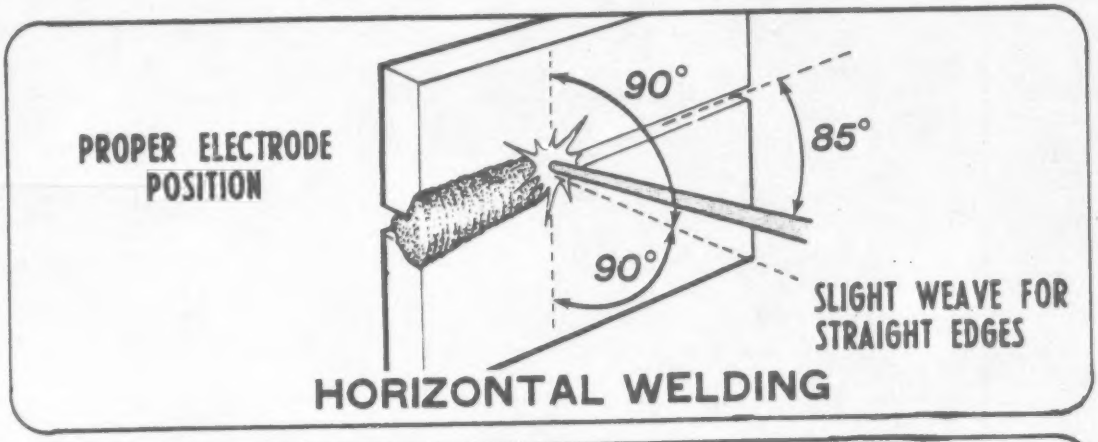
VERTICAL DOWN



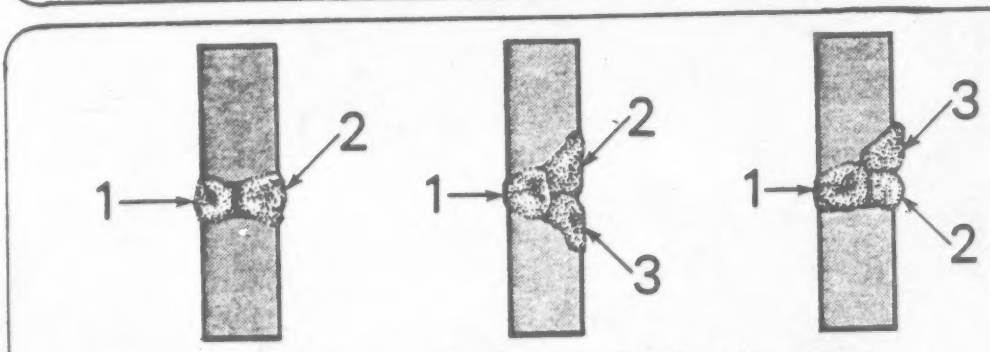




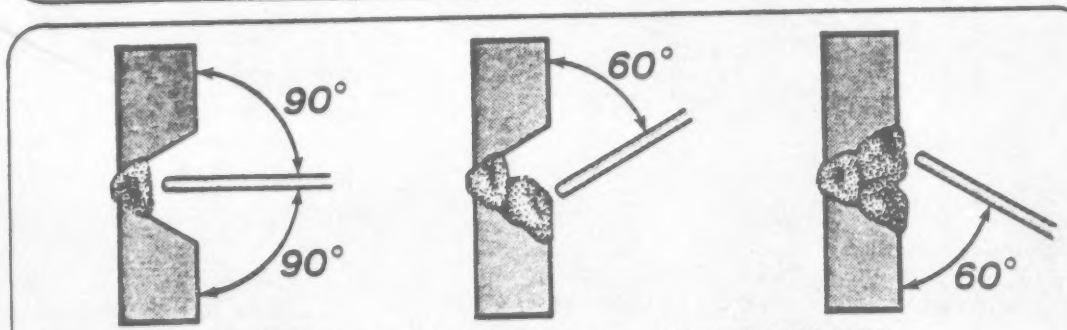
OTHER WELDING POSITIONS



HORIZONTAL WELDING

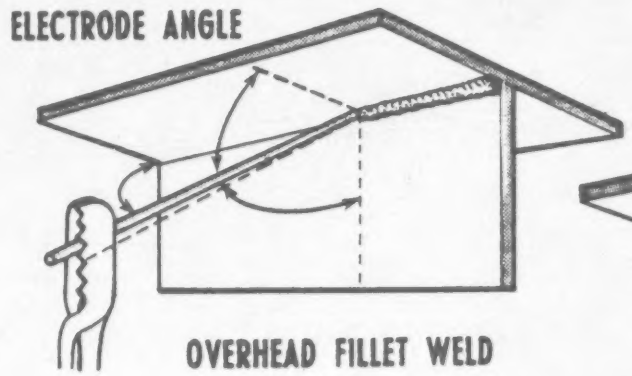


PASSES FOR WELDING HORIZONTAL BUTT JOINTS

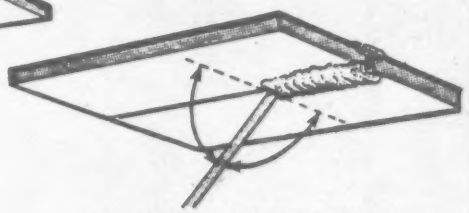


PROPER ELECTRODE POSITION - MULTIPLE WELDS

OTHER WELDING POSITIONS

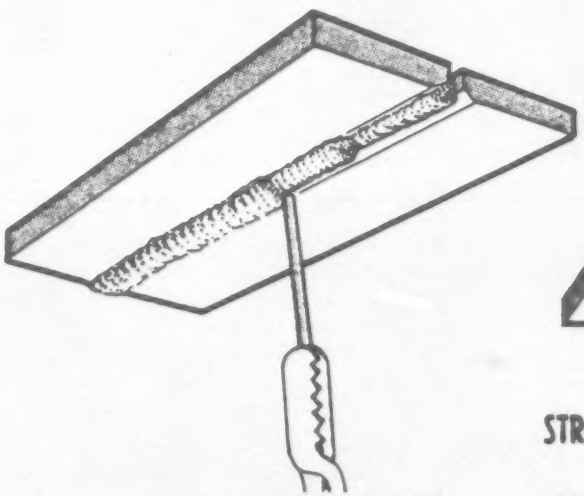


OVERHEAD FILLET WELD

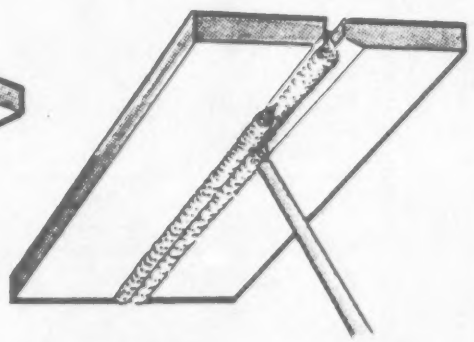


OVERHEAD BUTT WELD

OVERHEAD WELDING

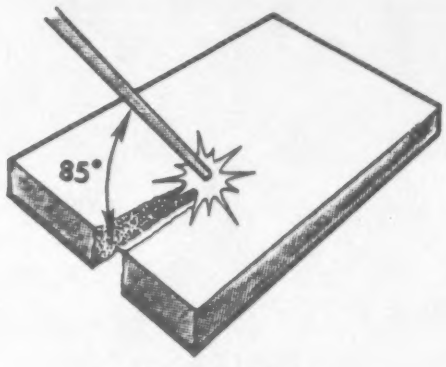


WEAVING BUTT WELD ON SECOND AND THIRD PASSES

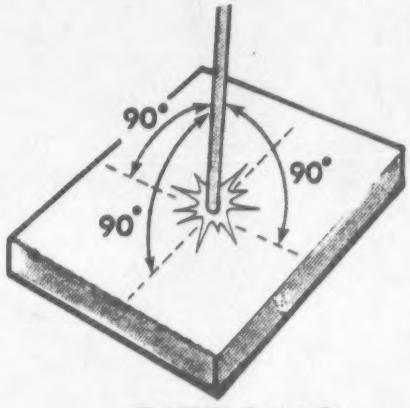


STRAIGHT BEADS FUSED TOGETHER

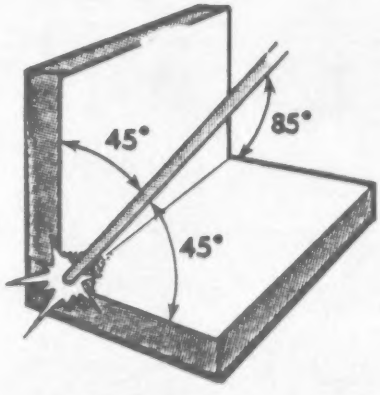
OTHER USES OF ARC WELDER



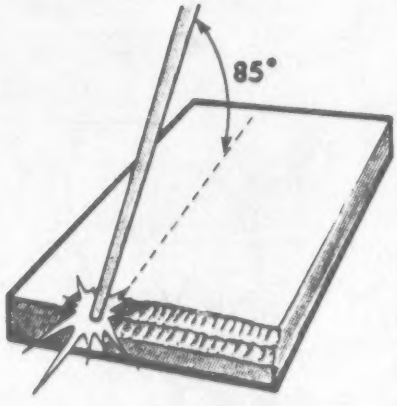
CUTTING



PIERCING

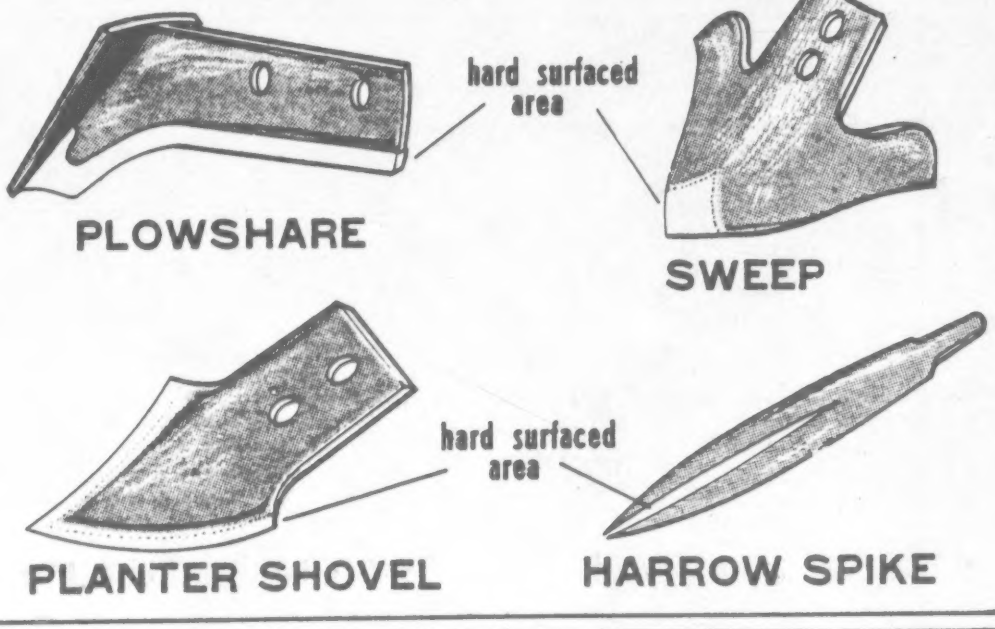


GOUGING

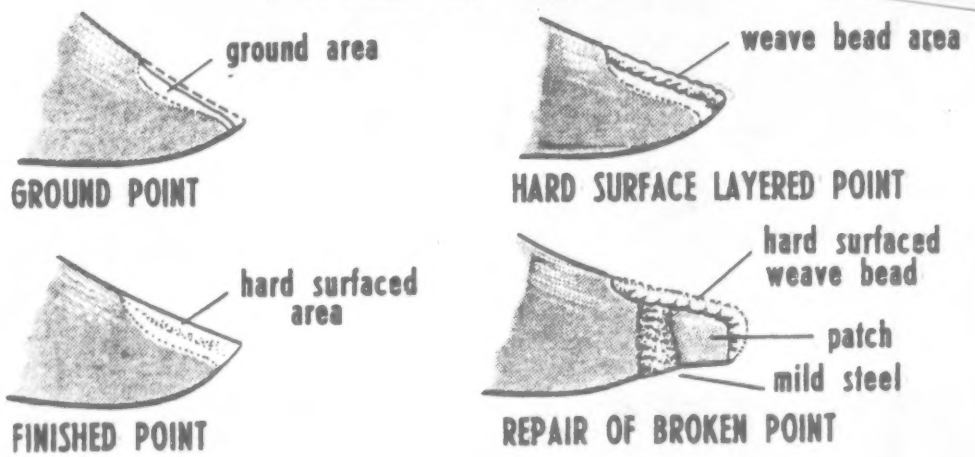


BEVELING

HARD SURFACING



REPAIR OF POINT



Student Activities

Following demonstrations by the instructor, the student should satisfactorily perform the following skills:

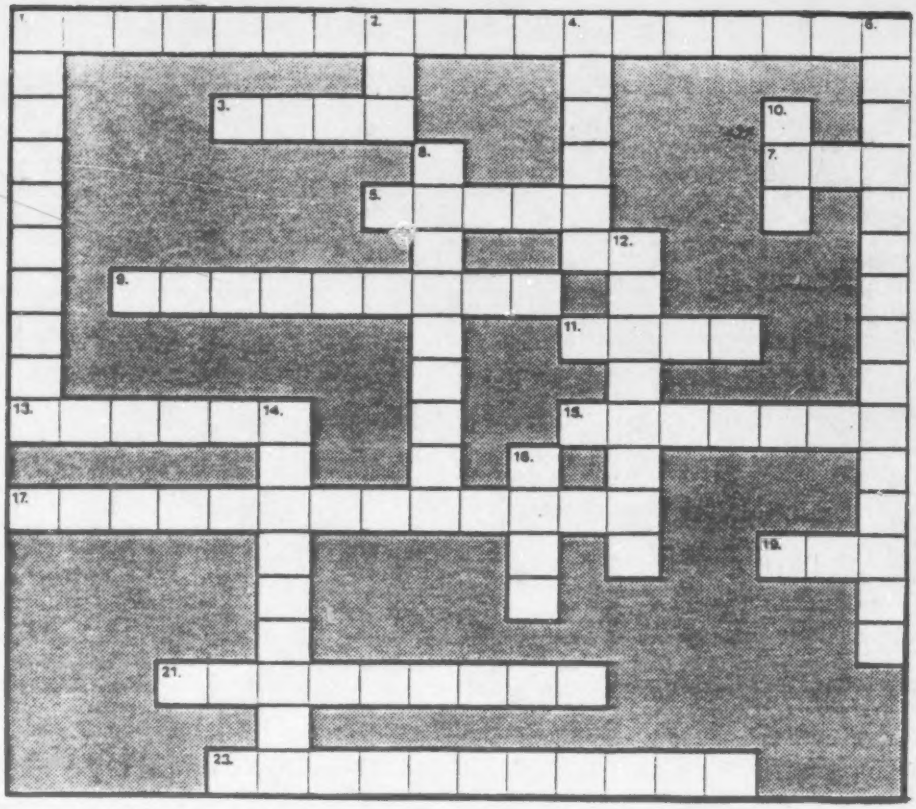
A. Butt weld
   1. Unbeveled
   2. Single bevel
   3. Double bevel

B. Fillet weld
   1. "T"
   2. Lap
   3. Corner

C. Out-of-position welding
   1. Vertical
   2. Horizontal
   3. Overhead

D. Cutting, Piercing, Gouging, and Beveling

E. Hard Surfacing



CROSS WORD PUZZLE

Upon completion of the arc welding study unit, the student should complete the following:

ACROSS

1. Polarity reverses or alternates 60 times per second.
3. Flux and impurities that coat the weld and protect it.
5. A weld pattern used to make a wider weld or cover pass.
7. American Welding Society.
9. Powered by a motor in a DC welding machine.
11. Coating on an electrode.
13. Clamp to attach to work in order to complete the circuit.
15. Tool used to clean and prepare weld joints.
17. The current flows steadily and constantly in one direction.
19. Metallic inert gas welding.
21. Distance equal to the diameter of the bare end of the electrode.
23. Adequate _____ is needed in the welding area.

DOWN

1. The fusing of two or more pieces of metal with the heat of an arc produced by an electric welding machine.
2. Tungsten inert gas welding.
4. Depression formed at the tip of the electrode at the end of the weld.
6. Strength of a weld (psi).
8. An electronic device to convert AC to DC.
10. A series of weld passes used to cover a plate while practice welding.
12. The direction of electrical current flow.
14. The ratio of arc time to total time.
16. National Electrical Manufacturer's Association.

OPTIONAL MATERIALS

METAL INERT GAS (MIG) WELDING

1. Why Is MIG Welding Popular?
2. What Kind of Equipment Is Needed?
3. How Is the Equipment Set Up?
4. What Are the Steps in MIG Welding?
5. How Are Various Metals Welded?
6. What Is Flux-Cored Wire Welding?
7. What Maintenance Is Needed?

Gas shielded metal-arc welding is frequently called "metal inert-gas" welding (MIG for short). It is a process in which a consummable wire electrode is fed into an arc and weld pool at a steady but adjustable rate, while a continuous envelope of inert gas flows out around the wire and shields the weld from contamination by the atmosphere.

Gas-shielded metal-arc welding is not a new process. Some efforts were made in the 1920's to shield the atmosphere from the electric arc to improve the properties of the welds. The introduction of the flux-covered electrode eliminated interest in the gas-shielding process at that time. Coated electrodes, actually utilize the gas produced by the disintegration of the coating and are actually gas-shielded welds (Fig. 1).

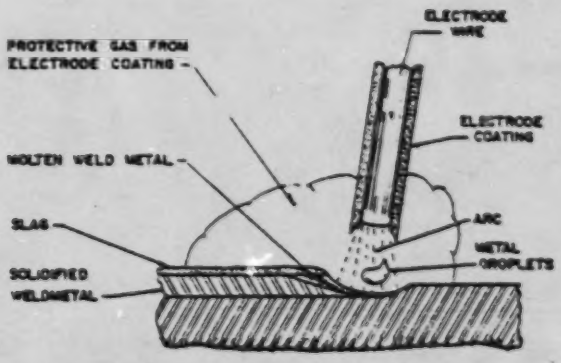


Fig. 1 The protective gas shield comes from the burning of the electrode coating in metal-arc welding.

There are several variations of the basic MIG process. These are: spray arc, short arc, globular transfer, cored-wire, and CO_2 welding. Manual MIG welding is really a semi-automatic process. Welding current and wire-feed speed are electrically interlocked so that the welding arc is self-correcting.

Spray arc

This is a high-heat method of welding with a rapid deposition of metal. It is for welding all common metals from about 3/32" to over 1" thickness. The term "spray arc" describes the way the metal is transferred to the work. The metal transfer is a spray of very fine droplets. This transfer occurs only with Argon or argon-oxygen mixture of shielding gas. The droplets are smaller than the diameter of the electrode wire (Fig. 2). The arc length is longer than in short arc welding.

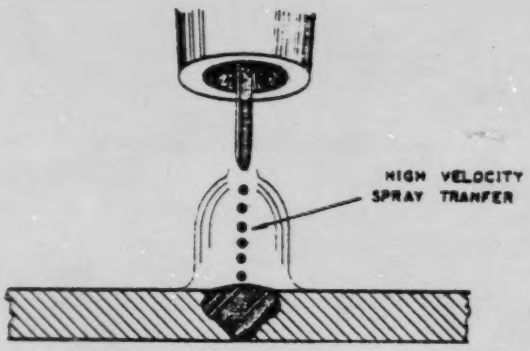


Fig. 2 High current density produces a quiet, steady arc in which the metal is transferred in fine droplets.

Short arc

This is a lower heat process than the spray-arc method and has a pinpoint arc. It also has a lower current density and may be used for all common metals. It was developed specifically for use with thin-guage metals to reduce or eliminate problems of distortion, burn-through, and spatter. The process is actually a series of periodic short circuits that occur as the molten tip of the work-piece and momentarily extinguishes the arc. When the short circuit occurs, the surface tension of the molten tip of the electrode tends to draw the metal quickly to the workpiece. This causes the molten filler metal to neck down or become very small in cross section. Under these conditions the molten metal reacts like a fuse and separates under the high-current densities in the arc stream. When this separation occurs, a gap occurs between the electrode wire and the workpiece and the welding arc is reignited. As the arc reignites, the cycle begins again. The shorting occurs from 20 to 200 times per second (Fig. 3).

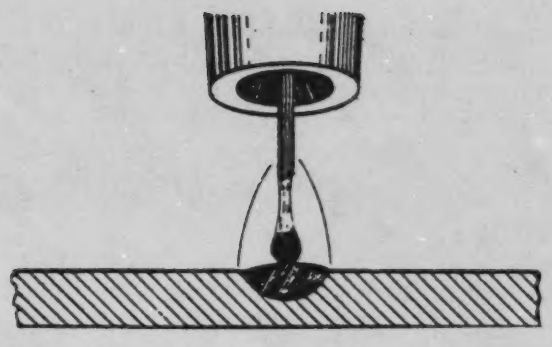


Fig. 3 The metal is transferred by droplets that melt off as the wire makes a short circuit when it contacts the work piece. The arc is reignited after the electrode wire separates.

Globular transfer

In this type of transfer, when the molten ball in the tip of the consumable electrode has grown large enough, it separates from the electrode and is transferred across the arc. As this molten ball or globule is transferred across the the arc, it is subjected to the physical forces of the arc and normally takes on an irregular shape and a rotating motion. The arc is continually being extinguished and reignited with this process also (Fig. 4).

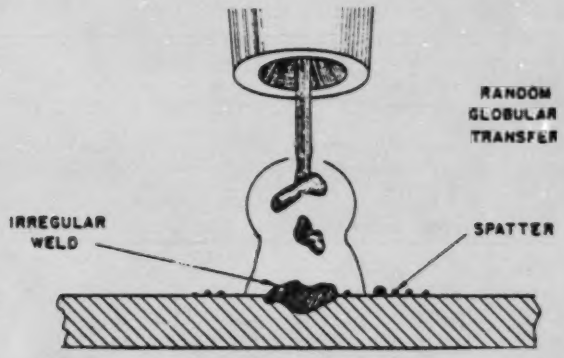


Fig. 4 This type of arc has low-current density and produces a flat bead with shallow penetration.

Cored wire

This is a high-heat, high-disposition rate process using flux-cored wires on carbon steel. Some flux cored wires require gas shielding and some do not. The process is somewhat similar to spray-arc welding. In addition to the gas shielding, the flux contained inside the wire adds alloying ingredients, and forms a slag blanket that acts as a cleaning agent. This process can deposit metal at a higher rate than most other processes, and is recommended for large fillet welds in the flat or horizontal positions.

CO_2 welding

This process uses CO_2 as the shielding gas rather than argon or argon

mixtures. It is used primarily on carbon or low-alloy steels, usually in the range of 3/32" to 1/4" thickness. The use of CO_2 generally produces deeper weld penetration but with some spatter. It is usually recommended when finish appearance is of minor importance and cleanup is not required. The deeper penetration can offset a lack of operator skill in exactly following a weld joint.

1. WHY IS A MIG WELDING POPULAR?

Usually when MIG welding is considered as a replacement for metal-arc (stick electrode) welding, the decision rests on the answer to the question, "Which process can do the job at the lowest cost?"

To determine that, you need to compare such items as cost of equipment, electrodes vs filler wire and shielding gas, and labor required for material preparation, welding, and cleaning.

A constant voltage welding machine may cost ten times as much as a metal-arc welder. With it; however, much of the control is automatic. All you have to watch is the angle of the gun, stick-out, and the speed of travel. It has a higher duty cycle (50-60%) compared to the metal-arc (25%). You can usually weld as rapidly and steadily as you are capable of welding. Manual MIG welding speeds may be as high as 30 ipm (inches per minute).

Management acceptance of MIG welding has been high because the finished product is acceptable and competitive at a lower price. On heavier metals the time and gas used for beveling and plate preparation is saved because less preparation is needed for MIG welding. Less obvious are the savings when electrode wire is compared to stick electrodes. Stub end losses, added to spatter and flux coating losses may amount to as much as 44% of the weight of stick electrodes.

The increasing popularity of MIG welding is due to the following advantages: The welding generally may be done in all positions. Except with flux-cored wire there is no slag to remove. This saves labor in the preparation for painting and it saves housekeeping time in the welding area. The process gives a smooth, good appearing weld surface. It is often possible to paint over MIG welds without any additional surface preparation.

The weld visibility is generally good. There is less smoke and fumes so operator environment is improved.

Due to high current density in a narrow area, there is deep penetration. Faster travel by speed means narrower zone affected by heat. With less heat transferring to the base metal, there is less distortion.

It is possible to bridge gaps and misalignment without burn-through. The weld quality is high. The equipment may be used on metal from 20 guage to 1" thick.

A new development in the welding field is the integral smoke retrieval system. This new smoke exhaust system helps provide a cleaner work area and an improved environment for the workers.

With all of the advantages listed above it is easy to see why MIG

welding has been accepted to both operator and management, and why the process is increasing in popularity.

2. WHAT KIND OF EQUIPMENT IS NEEDED?

To understand the MIG welding process, you must understand the equipment needed. It consists of a welder, a wire-feed system, cable and welding gun assembly, shielding gas supply, and electrode wire. The equipment is shown schematically in Fig. 5.

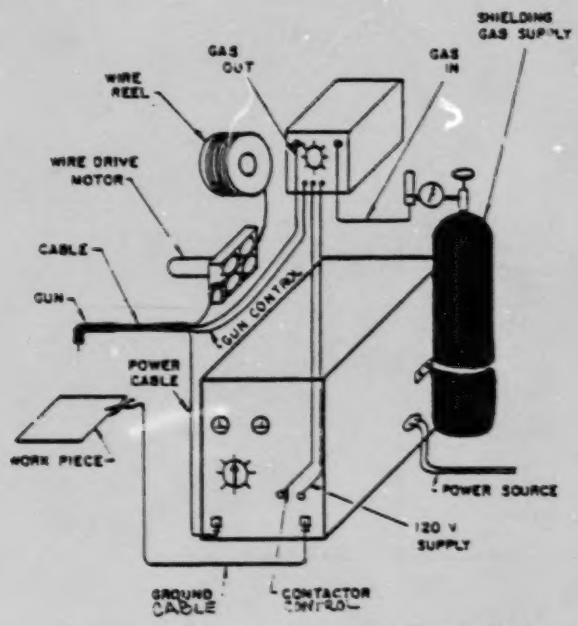


Fig. 5 The major parts of a MIG welder are shown schematically.

To select a welder that will perform properly, it is necessary to understand how this welder operates. Perhaps the best way to understand this is to compare the MIG welding process with metal-arc welding.

Voltage

In metal-arc welding, heat is generated by the flow of current through the gap between the end of the electrode and the workpiece. If you hold a long arc, the voltage will increase. If you push the electrode close to the puddle (short arc), the voltage will decrease. You control the arc length by the rate you feed the electrode into the puddle.

Welding voltage has an effect on bead width, spatter, undercutting, and penetration.

When the arc voltage is high in MIG welding, the size of the droplets increases, and in the magnetic field surrounding the arc stream, some of the droplets miss the puddle and others splash molten metal out of the puddle, causing spatter.

A long arc (higher voltage) gives a wide bead with low reinforcement. A short arc (lower voltage) gives a narrow bead with high

reinforcement. Therefore, the higher the arc voltage, the longer the arc and the wider the bead (Fig. 6). Since the energy is concentrated in the area directly under the arc stream, the wide arc stream from the higher voltage will cause the penetration to be shallow because it is so spread out. If a lower voltage is used, with a shorter arc, the penetration will be deeper because the arc stream is concentrated (Fig. 7).

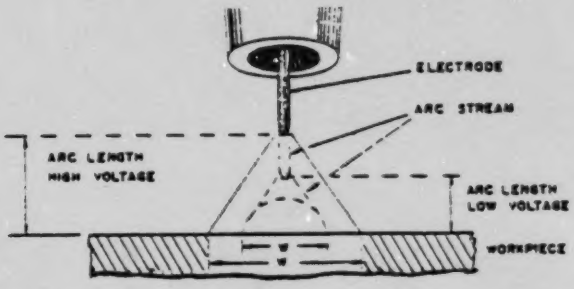


Fig. 6 Arc voltage is used to control bead shape.

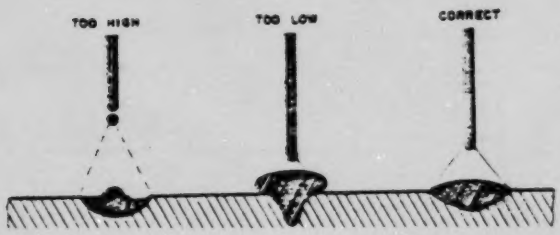


Fig. 7 When the arc voltage is too high for travel speed, the penetration will be shallow. Correct voltage-travel speed relationship produces a desirable weld contour and penetration.

To produce a uniform MIG weld, maintain the welding voltage, (and arc length) at a constant value. This may be accomplished in two ways: 1) by feeding the wire into the pool at exactly the rate at which it melts, or 2) melting the wire at exactly the rate at which it is fed into the weld pool. The method of controlling the voltage (arc length) depends on the type of power supply.

Current

The rate of electrode burn-off is determined by the current setting. The higher the current setting, the faster the electrode will burn off. This is true of both stick electrodes and MIG welding.

MIG welding is a direct-current process. Alternating current is seldom if ever used, because the wire burn-off rate is very erratic.

Most MIG welding is done with reverse polarity (DCRP). This means that the welding wire is positive (+) and the work piece is negative (-). Weld penetration is deeper with reverse polarity. Arc instability and spatter problems make straight polarity (DCSP) undesirable for most applications.

The welding arc is a result of both voltage and amperage. For the correct welding performance, there is a certain relationship between voltage and amperage. If this relationship changed, the appearance and performance of the weld will change. You must remember that if you change either the amperage or the voltage, you must change the other in order to get consistent high quality welding results.

When you are adjusting the semiautomatic MIG welder, always use the greatest amount of amperage possible. This will result in the maximum deposition rate and welding speed, the best penetration, and the least amount of spatter.

Constant-current welders

These have been used for years with metal-arc welding and more recently with Tungsten Inert-Gas (TIG) welding. They have what is called a drooping volt-ampere curve. The curve approaches a constant current level (Fig. 8). These welders have a relatively nonadjustable slope. They have a high open circuit voltage and low short circuit currents.

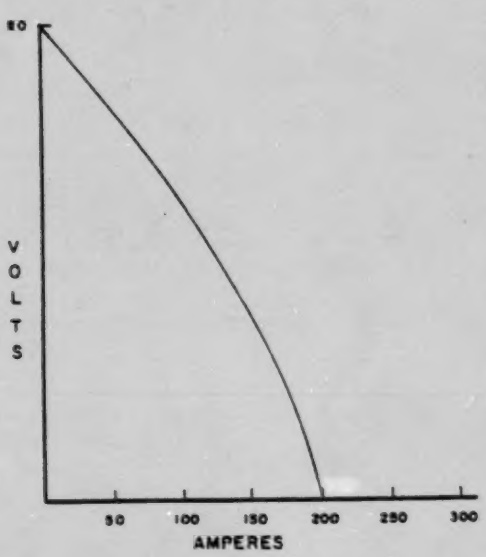


Fig. 8 When a stick electrode freezes to the work with this welder, the maximum current flows through the electrode and it heats up. The maximum current is limited by the machine.

These welders have a limited range of self-correction of arc length. To use these for MIG welding, it is necessary to adjust the wire speeds within narrow limits to prevent the wire from plunging into the plate or burning back into the nozzle. Electronic governors are used in the wire feeding apparatus to feed the wire at a controlled rate. The arc voltage is set by the wire feed speed and the current is set on the power supply. The operator adjusts the wire speed to obtain the arc length desired. When the nozzle-to-

work distance increases, the arc length increases.

You are well aware that it is extremely difficult to hold exactly the same arc length all the time in all positions in manual operation (semiautomatic). In critical welding operations, this increase in voltage could be very undesirable. Because of these problems, constant-voltage welders were developed.

Constant-voltage welders

These welders have been developed in recent years and have near flat volt-amperage curves. They have a wider range of arc self-correction than the constant current type (Fig. 9). They have low open circuit voltage and high short circuit currents.

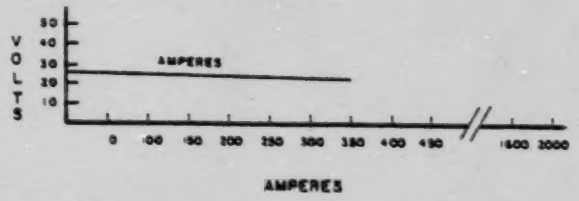


Fig. 9 These welders have low open-circuit voltage and high short circuit currents. If a covered electrode were shortened on this welder, the current would rise to the maximum (2000 amperes) and the electrode would explode to clear the short circuit.

The constant-voltage system of power is fairly new to the welding industry, but it is not new to the electric-power industry. It is the basis of the entire commercial electric power system. The voltage delivered to your house is available at every receptacle in the house at the same voltage. It does not matter whether an electric clock, electric light bulb, toaster, or heavy-duty heater is plugged into the receptacle. The voltage supplied and hence the voltage drop across each appliance is the same. The current flowing through each electrical appliance, (clock, bulb, toaster, heater) is determined by the resistance of that particular circuit. Ohm's law states that: voltage = current x resistance. This is represented mathematically by the formula E = I x R.

The clock would draw less than one watt of power with a current of 1/20 ampere. The electric heater may draw as high as 1500 watts with a current as high as 12 1/2 amperes. In other words, the voltage remains constant but the current flowing through the appliance depends upon the resistance in the electrical circuit of that appliance. The same principle is applied to the constant-voltage welding system.

There are three essential points to remember about the constant-voltage system: (1) A constant-voltage power supply is used; (2) A consumable electrode is fed into the arc at a constant preset speed; and (3) The current produced with this type of arc control will be just enough to burn off the wire at the same rate it is fed into the arc.

The MIG welding process requires a welder that has a reliable automatic arc-length control. This constant-voltage system of

automatic control is widely used today. It can be used for all welding processes that feed a continuous consumable electrode into the arc. You can change wire feed over a wider range without either stubbing or burning back the wire. You set the arc length (voltage) on a constant-voltage welder in contrast to setting the current on the constant-current welder.

The arc current is controlled by the wire feed speed. You feed wire at a controlled speed. With slow wire speed, the current output is low. If a high wire speed is used, the welding current is high. Although a uniform distance from the torch nozzle is recommended, you have more leeway for error than with constant-current welders.

Single-phase welders perform well on a single phase primary service, but it is a known fact that 3 - phase current is much smoother than single-phase, and will produce a much nicer weld (Fig. 10).

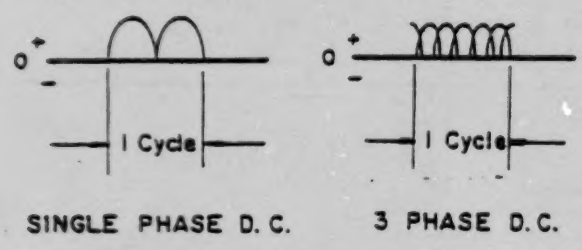


Fig. 10 Three-phase current is smoother than single phase.

Since the arc is self-correcting, the constant-voltage welders require less operator skill than constant current welders. If the arc length becomes shorter than the preselected value, the current automatically increases and the wire burns off faster than it is fed. If the arc becomes too long, the current will be feeding faster than it is burning off and the arc length will again become shorter.

The constant-voltage welders provide control over slope, voltage, and inductance.

Slope has been defined as the slant of the volts-ampere curve. It is generally referred to as "volts-change per 100 amperes." The slope controls the amount of "pinch force" applied to the wire, by the amount of current available. This pinch force causes the wire to neck down and finally separate from the work piece. The amount of current at this point is important because the manner in which the wire parts from the work can be either violent or smooth. If the current is at the correct amount, the parting is smooth with little or no spatter and tightly grouped freeze lines are in the bead. The amount of current available on short circuit is controlled by means of slope selection.

A good example of the effect of changing slope can be illustrated

by three electrical circuits using 10-ampere fuses in each circuit. On the first circuit, eight amperes are used. This fuse does not blow because there isn't an excess of current flow. On the second circuit, 12 amperes are used. This fuse blows. The ends of the fuse metal have small balls of metal on them. This is an example of smooth parting and the glass on the fuse will be clean. On the third circuit, 20 amperes are used. This fuse blows also. There are little pellets of metal scattered all over the inside of the fuse case and the glass is discolored by them. This is violent parting and the little pellets of metal are comparable to spatter in the arc zone. Therefore, it is desirable to adjust slope to match wire size with proper current.

In any conductor, the "pinch effect" force is proportional to the square of the current flowing through it. If the current is doubled, the pinch force will be increased four times. When the conductor is molten, the pinch effect will cause the molten conductor to neck down as soon as the pinch force exceeds the surface tension of the molten wire. The surface-tension force attempts to maintain the shape of the molten conductor. Increasing the slope reduces the short-circuit current and thus, limits the final amount of pinch force must be applied by control of the slope so that the arc is cleanly ignited after each short circuit (Fig. 11).

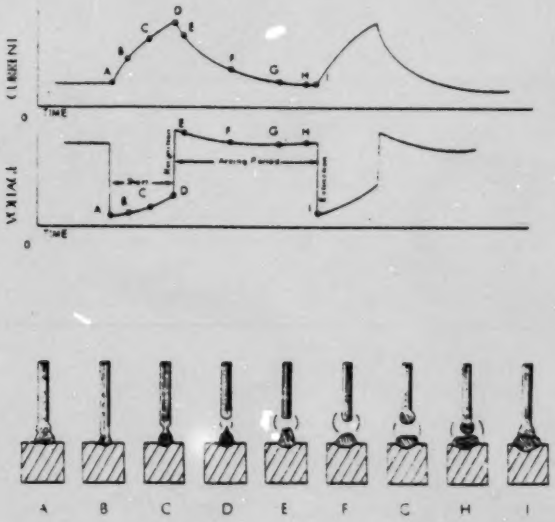


Fig. 11 The steps in short-circuit welding are shown here. Note the effect of each step on the voltage and amperage.

Voltage wets the base metal. With a long arc length (high voltage), the weld bead is wide, while the bead is narrow with a short arc (Fig. 6).

Inductance controls the rate of rise of current without affecting the final amount of current and hence the rate of application of pinch force. If the pinch force is applied rapidly, the spatter will be great. Greater inductance slows down the rate of current rise and reduces spatter (Fig. 11).

In short arc welding, an increase in inductance will decrease the number of short circuit metal transfers per second, and increase the "arc-on" time. The increased arc-on time makes the puddle wetter and more fluid. The penetration is deeper, bead is smoother and flatter, and the freeze lines are more tightly grouped. A decreased inductance will increase the number of short circuits per second and decrease the arc-on time. The decreased arc-on time makes the puddle less fluid.

In spray-arc welding, the addition of inductance will produce a softer, more usable start without reducing the final amount of current. If slope is added to reduce the violence of the start by limiting the short circuit current, it is not possible to get the full constant potential output from the welder. The use of inductance to control spray arc permits the operator to use the full constant potential output of the power source.

Wire feeding mechanism

The specially designed wire feeding mechanism and the constant-voltage welder make up the heart of the MIG welding outfit. The wire feeder continually draws a small diameter electrode wire from the spool (Fig. 12) and drives it through the cable assembly and gun at a constant rate of speed. The constant rate of wire feed is necessary to assure a smooth even arc. This must be adjustable to provide for different welding current settings that may be desired. Several different types of wire-feed systems are available.

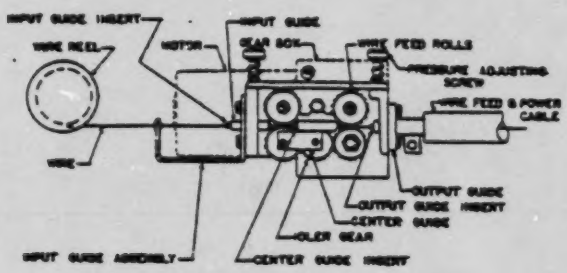


Fig. 12 The parts of a wire feeder are shown here.

One heavy-duty type of wire feeder utilizes a direct-current-drive motor with speed control accomplished by means of an autotransformer and a rectifier circuit. Another system uses an AC motor with a speed-control governor built into the motor housing. A third system utilizes a DC motor with a rectifier and rheostat for speed control. All three systems allow for motor speed adjustment which in turn controls the wire feed speed and the welding current.

The wire feeder also includes a control system for starting and stopping the wire-feed motor, for operating the welding power contactor, and for energizing the gas-control valve. The proper sequencing of these operations and the introduction of delay time provide for the necessary control which is initiated by the start

switch on the welding gun. For a matched system, the wire feeder should be designed to interconnect with the power source by merely attaching the appropriate cables from each unit.

Normally the wire feeder is mounted on the power source; however, in a factory where the welding must be done over a larger area, the wire feeder may be separate from the power source, as much as 200 feet.

The wire feeders have different sized drive rolls so they can accomodate different sizes and types of wire. Different rolls are normally required for hard wires than for soft wires.

Welding gun and cable assembly

This assembly is needed to carry the electrode wire, the welding current, and the shielding gas from the wire feeder to the arc area. The operator directs the arc and controls the weld with the welding gun. The welding gun must be an extremely durable piece of equipment since it is continually adjacent to the welding arc. It should be designed so that you can quickly and easily clean and replace the nozzle and contact tube and adjust the electrode contact tube.

Welding guns are designed for different types of service and different duty cycles. Light-weight guns are available for out-of-position work at low-current levels, while heavy-duty guns are available for high-production requirements. In general, most guns for MIG welding are not provided with water cooling. The electrode wire and the CO_2 gas actually help cool the gun. When high-duty cycles and higher currents are used, water cooling may be required. Unless the current value is very low, a water cooled gun is always necessary when argon and or helium is used for shielding.

The cable assemblies leading from the wire feeder to the gun are available in several types and lengths. One type of assembly uses separate hoses or cables, whereas another type uses a single molded conductor that includes all of the necessary components. The selection of the type of cable assembly is primarily your choice for your job. Cable assemblies use a flexible liner in the conductor for the electrode wire. These liners are made from spring steel similar to a small engine control cable. Plastic liners are sometimes used. The liners serve as guides for electrode wire from the drive rolls to the contact tube in the gun and provide for uninterrupted travel of the wire without buckling or kinking.

Shielding gas

In metal-arc welding, a coating on the electrode produces a shielded atmosphere when it disintegrates in the welding arc. In MIG welding, the same effect is accomplished by surrounding the arc area with gases supplied from an external source.

The air in the arc area is displaced by the shielding gas. The arc is struck under the blanket of shielding gas. Since the molten weld metal is exposed only to the shielding gas, it is not contaminated, and strong dense weld deposits are obtained. The reason for shielding the arc area is to prohibit air from coming in contact with the molten metal.

Atmospheric air is made up of approximately 21% oxygen, 78% nitrogen, .94% argon, plus other gases. The atmosphere will also contain a certain amount of water, depending of the humidity. Of all the elements that are in the air, the three which cause the most difficulty in welding are oxygen, nitrogen, and hydrogen.

Oxygen is a highly reactive element and combines readily with other elements in the metal or alloy to form undesirable oxides and gases. The oxide forming aspect of the oxygen can be overcome with the use of deoxidizers in the steel weld metal. The deoxidizers, such as manganese and silicon, combine with the oxygen and form a light slag which floats to the top of the weld pool. If the deoxidizers are not provided, the oxygen will combine with the iron and form compounds which can lead to inclusions in the weld material which can lower its mechanical properties. On cooling, the free oxygen in the arc area combines with the carbon of the alloy material and forms carbon monoxide. If this gas is trapped in the weld metal as it cools, it collects in pockets which cause pores or hollow spaces in the weld deposit.

Nitrogen causes the most serious problems in welding steel. When iron is molten, it is able to take a relatively large amount of nitrogen into solution. At room temperature the solubility of nitrogen in iron is very low. When iron cools, the nitrogen percipitates out of the iron nitrites. These nitrites cause high yield strength, tensile strength, hardness, and a noticeable decrease in the ductility and impact resistance of the steel. The loss of ductility, due to the iron nitrites often leads to cracking in and adjacent to the weld metal. As stated above, air contains approximately 78% nitrogen by volume and therefore, if the weld metal is not protected from the air during welding, the weld quality will be poorer. Excessive amounts of nitrogen can cause gross porosity in the weld deposits.

Hydrogen is also harmful to welding process. Very small amounts of hydrogen in the atmosphere produce an erratic arc. Of most importance is the effect that hydrogen has on the properties of the weld deposit. As in the case of nitrogen, iron can hold a relatively large amount of hydrogen when it is molten but upon cooling, it has a low solubility for hydrogen, and as the metal starts to solidify, it rejects the hydrogen. Hydrogen that becomes entrapped in the solidifying metal collects at certain points and causes large pressures or stresses to occur. These pressures lead to minute cracks in the weld metal which can later develop into large cracks. Hydrogen also causes defects known as "fish eyes" and under-bead cracking.

The effects of oxygen, nitrogen, and hydrogen make it essential that they be excluded from the weld area during welding.

Various shielding gases can be used. Carbon dioxide (CO_2) gas is the least expensive and is widely used. Pure argon, argon-helium, argon-oxygen, and argon-carbon dioxide mixtures are commonly used with the MIG welding. Each gas and mixture affects the smoothness of the weld; weld appearance, quality, and welding speed in a different way. The density of the shielding gas determines the effectiveness of the gas and the flow rate (cu. ft./hr.) required.

The six inert gases found in nature are helium, neon, argon, krypton, xenon, and radon. A helium atom has one shell that contains two electrons. The rest of the inert gages have 8 electrons in their outer shell. Since the inert gases are very stable and do not readily take on or give up electrons to form compounds with other elements, they are very useful as shielding atmosphere for arc welding, but argon and helium are used because they can be obtained in quantities at an economical price.

Argon. This gas has been used for many years as a shielding gas for fusion welding. Argon is obtained by the liquification and distillation of air. While argon is present in the air in a small amount (.94%), there is approximately 800,000 pounds of argon over one square mile of the earth's surface. Argon boils off of liquid air at -302.4° F. Welding quality of argon is 99.995% pure.

The welding arc tends to be more stable when argon is used as sheilding gas. For this reason, argon is often used in conjunction with other gases for arc shielding. The argon gives a quiet arc and reduces spatter. Since argon has a low ionization potential, the arc voltage may be reduced when argon is added to the shielding gas. This results in lower power in the arc and lower penetration. The combination of lower power and reduces spatter makes the use of argon desirable when welding sheet metal.

Straight argon is seldom used for arc shielding, especially for steel. The use of straight argon leads to undercutting and poor bead contour. The penetration pattern is shallow at the edges of the bead with a deep finger in the center of the weld (Fig. 13).

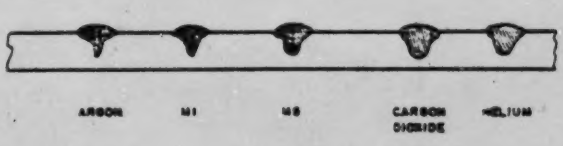


Fig. 13 The penetration caused by different shielding gases is shown here. M1 is 1% oxygen mixture with argon and M5 is 5% oxygen.

Argon plus oxygen modifies the bead contour and penetration pattern. Small amounts of oxygen (one or two percent, but never more than five percent), improve the penetration pattern by broadening the deep penetration finger at the center of the weld bead. It improves the bead contour and eliminates the undercut at the edge of the weld.

Helium

Shielding with helium produces greater arc voltage per unit of arc length, results in hotter arc, deeper penetration, greater travel speed, and reduced heat effects on the workpiece. The metal transfers from the electrodes in larger drops and tends to spatter. Penetration is more uniform, lacking the deep penetrating center finger of argon shielded welds. For a given current and arc length,

the arc voltage is higher and the wire burnoff rate is greater.

Carbon dioxide is not an inert gas but is used extensively in shielding mild-steel welding. In the development of MIG welding, it was found that the use of argon or helium made it difficult to compete economically with other welding processes. While doing research on the development of coated electrodes, investigators collected gases generated by the various coated electrodes. Analysis of the composition of gases generated by the lime-type coated electrodes show that carbon dioxide and carbon monoxide constituted 80 to 90% of the gases that were generated. Because of this, carbon dioxide was tried and proved highly successful as a shielding gas for MIG welding.

Unlike argon and helium gases, which are made of single atoms, the carbon dioxide gas is made up of molecules. Each molecule contains one carbon atom and two oxygen atoms. The chemical formula is CO_2 and often carbon dioxide is referred to as, "Cee-OH-Two".

Unlike argon and helium gases, it is essentially an inert gas. At high temperatures, it will disassociate into carbon monoxide and oxygen. Because of the oxidizing characteristic of this gas, the wires used with it must contain deoxidizing elements. The deoxidizing agents have a great affinity for the oxygen and readily combine with it. This prevents the oxygen atoms from combining with the carbon or iron in the weld metal and produce low quality welds. The most common deoxidizers used are manganese, silicon, titanium, aluminum, and vanadium.

Carbon dioxide is manufactured in most plants from flue gases which are given off by the burning of natural gas, fuel oil, or coke. It is also obtained from the manufacturing of ammonia, from the fermentation of alcohol, and as a by-product of calcining operations at lime kilns. The carbon dioxide given off by the manufacturing of ammonia and the fermentation of alcohol is almost 100% pure.

The purity standard set up for welding is a minimum dew point of minus 40° F. This means that gas of this purity will contain moisture of approximately 66 parts per thousand. Carbon dioxide is made available to you in either cylinder or bulk containers.

The cylinder is most widely used. CO_2 exists in the cylinder in both liquid and vapor form. A standard welding grade cylinder will contain approximately 50 pounds or 435 cubic feet of gaseous carbon dioxide under a pressure of 1000 psi. The heat necessary to convert the CO_2 liquid to gas must be transferred through the cylinder walls. This limitation in heat transfer makes it necessary to limit the withdrawal rate on a cylinder. For some carbon dioxide cylinders, the manufacturer's maximum withdrawal recommendation is 25 cubic feet per hour. For most welding operations, the flow is usually between 4 and 35 cfh so it may be necessary to connect several cylinders with a manifold. As the CO_2 vapor pressure drops from the cylinder pressure to discharge pressure, through the CO_2 regulator, it absorbs a great deal of heat. If flow rates are set too high, this can lead to freezing of the CO_2 regulator and flow meter. When this happens, the gas shield

may be interupted and weld porosity will result. In some instances electric heaters are used to prevent freezing. Some suppliers recommend that the cylinders be returned when the pressure drops to 200 psi. This will insure that there is a positive pressure in the cylinder and that water and other contaminants do not get into it.

With carbon dioxide, a broad, deep penetration pattern is obtained. This makes it easier for the operator to eliminate weld defects, such as lack of penetration and lack of fusion. Bead contour is good and there is no tendency towards undercutting.

The main objection to CO_2 gas is the tendency for the arc to be somewhat violent. This can lead to spatter problems when welding on thin materials where appearance is of particular importance.

The information in Table I may be useful in selecting or ordering shielding gases.

Various factors affect the rate of shielding gas flow. Consult tables provided by the manufacturer of your welder for their recommendations concerning gas flow. Some metals require greater gas flow than others even though the same nozzle is used. Outside corner welds lose shielding gas more easily than an inside corner or fillet weld. It may be necessary to increase the flow rate to compensate for this loss. In general the gas flow should increase with a rise in current.

The gas must be fed through the nozzle at such a flow rate that laminar flow occurs. If the flow rate is too great, swirling gas mixes with the surrounding air and causes contamination of the weld deposit (Fig. 14).

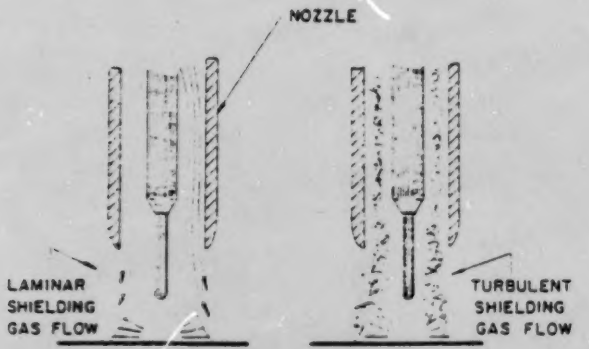


Fig. 14 To get good shielding, the flow must be laminar as in A. If the flow is turbulent B, the weld deposit will be contaminated.

The rate of flow is affected by the shape and cross-sectional area of the nozzle. For a particular nozzle, the flow rate should work for all wire-feed speeds. Check the manufacturer's recommendations and do not deviate too far from these suggested figures.

Table I. Gas Cylinder Information

GAS	CYLINDER CAPACITIES CUBIC FEET	FULL CYLINDER PRESSURE AT 70°F.(PSI)	CYLINDER WEIGHT		CYLINDER COLOR		LETTER IDENTIFICATION
			FULL LBS.	EMPTY LBS.	BODY	NECK RING	
CARBON DIOXIDE*	435	1,000	183	133	SILVER	GRAY	CO_2
ARGON	238	2,200	158	133	BROWN	—	ARGON
	330	2,640	177	143	BROWN	—	ARGON
ARGON & OXYGEN	238	2,200	158	133	BROWN	BLUE	M-1, M-2 — M-5
	330	2,640	177	143	BROWN	BLUE	M-1, M-2 — M-5
ARGON & CO_2 †	379	2,640	177	143	BROWN	SILVER	C-25
OXYGEN	224	2,200	153	133	GREEN	—	O_2
	224	2,200	134	114	GREEN	—	O_2

NOTE: * CO_2 CYLINDER CONTAINS BOTH LIQUID AND GAS.

† ARGON PLUS CO_2 IS 75% ARGON AND 25% CARBON DIOXIDE.

Table II provides a broad recommendation as to shielding gas for various metals.

Table II. Shielding Gas Recommendations

MATERIAL	GAS	INFORMATION
Aluminum and Al Alloys	Argon	Removes oxide on metal surface.
Aluminum and Al Alloys	75% Helium 25% Argon	High heat input reduces porosity tendency.
Mild Steel - (Large wire)	CO_2	High speed low cost welding but accompanied by some spatter.
Mild Steel - (Micro-wire)	CO_2	High quality, low current, all position welding, low spatter.
Mild Steel - (Micro-wire)	75% Argon 25% CO_2	Better appearance than above, minimum spatter, less penetration but more expensive.
Stainless Steel	Argon plus 1% or 5% Oxygen	Oxygen improves arc stability.
Stainless Steel	CO_2	Will have minor carbon pick up in deposited metal.

Electrode wires

The selection of the correct electrode wire is an important decision and the success of the welding operation depends on the correct selection.

First of all consider the type of metal to be welded and choose a filler wire to match the base metal in analysis and mechanical properties. Next, consider the joint design. Thicker metals and complicated joint designs usually require filler wires that provide high ductility. Third, examine the surface condition of the metal to be welded. If it is rusty or scaly, that will have an effect on the type of wire selected. Finally, consider the service requirements that the welded product will encounter.

The electrode wire for gas shielded arc welding is available in these different sizes: .020", .030", .035", .045", .052", 1/16", 5/64", 3/32".

Not all of these diameters are available for all metals or in all forms. You must consult your electrode catalog to determine just the form or package that you wish to buy. Most electrodes are available in spools of 2 1/2 lbs, 10 lbs, and 25 lbs. You can also order electrodes in coils of 25#, 65#, 150#, and 200#. For large jobs you may wish to order 300, 700 or 1000 lb. drums.

These welding wires are manufactured to close tolerances so that they feed smoothly through the wire-feed equipment. The wires must be clean, free of slivers, scale or oxides, or drawing compound. The wires must be wound evenly, without kinks, waves or bends, so they feed through the cable easily without fouling. The wires must pay off the reels or spools or drums without snarling or kinking.

AWS-ASTM Codes

The American Welding Society and the American Society for Testing Materials have jointly prepared specifications for filler metals. The AWS specification is in two parts beginning with A5. The last two numbers indicate the year of issue and the letter "T" indicates the specification is tentative. For mild- or low-alloy steel, the AWS Code might be AWS-A5.1-58T or AWS A5.18.-69. The ASTM specification number is also in two parts. The letters and figures to the left of the dash indicate the material, product or process, and the part to the right shows the year in which the specification was last revised. The numbers beginning with "A" cover iron and steel while those beginning with "B" cover nonferrous metals and alloys. For mild or low alloy steel the ASTM Code might be ASTM A233-58T or ASTM A316-58T. For aluminum the AWS-ASTM Code might be AWS-A5.10-69, ASTM B285-69.

The electrode wire analysis, mechanical properties, Charpy V notch calues in foot pounds and typical applications are available in most welding wire catalogs, to help you select the proper wire for your application.

If you examine a catalog for metal-arc electrodes, you will find information about the electrodes similar to the following:

E6010 - coating brown
Tensile strength - 62-76, 500 psi
Yield point - 51-67, 500 psi
Elongation - 2" 22 - 32%
Charpy V (Ft. lbs.) - 31 at-20° F.

Analysis:

Carbon	.07
Silicon	.25
Manganese	.50
Phosphorus	.016

Application: Joints requiring deep penetration, shipbuilding, pipewelding, etc. where dirt, rust and paint cannot be removed prior to welding.

The information in Table III shows that Type 25 wire corresponds in many ways to the requirements for an E60XX or an E70XX electrode. In this way you can select a wire to match the requirements for which you have been selecting stick electrodes.

Table III. Solid Wire for Mild and Low Alloy Steel

TYPE	TYPICAL WIRE & WELD DEPOSIT COMPOSITION							APPLICATION	TYPICAL MECHANICAL PROPERTIES			
		C	Mn	Si	P*	S	Others		Tensile	Yield	Elongation %	Red of Area
18	Wire	.12	1.90	.80	.020	.020	Mo .50; Ni..10	High Quality Micro Pipe Welding X-Ray Quality	100,000	85,000	22	55
	Deposit	.10	1.40	.55	.020	.020	Mo .50					
25	Wire	.16	1.20	.50	.020	.019		Standard Fabrication Most Popular General Purpose Wire	75,000	63,000	26	58
	Deposit	.12	.70	.20	.020	.020						
28	Wire	.11	1.65	1.12	.021	.024		Smooth & Efficient New Wire With Powerful Deoxidizers	88,000	68,000	28	60
	Deposit	.10	1.20	.60	.020	.025						

The AWS classifications for continuous wire follow the standard pattern used for metal-arc electrodes. The prefix "E" designates an electrode. The number 70 refers to the minimum as welded tensile strength in 1,000 psi. The letter "S" if used to designate a bare, solid, continuous wire electrode. The letter "T" indicates a continuous tubular type wire electrode which contains a powdered flux in the tube. The letter "U" indicates an emissive coated, solid wire continuous electrode that has the surface coated with an arc stabilizing compound. Following these letters and numbers is a numerical suffix that indicates a chemical compostition. Characteristics of welding wires are shown in Table IV.

A brief description of some of the wires commonly carried by distributors is as follows:

E70S-1 Used where weld quality requirements are not critical and lower material costs are desired.

E70S-2 Used for out-of-position welding using short arc transfer. This wire is suitable for rimmed, semi-killed and killed steels at various carbon levels.

Table IV. Characteristics of Welding Wire

AWS Class	Gas Shield[1]	Current	Mn	Chemical Composition Percent C	Si	P	Ni	Ti	Zr	Al
				Solid Wire						
E70S-1	AO	DCRP	---	.07-.19	.3-.5	.025	---	---	---	---
E70S-2	AO/CO_2	DCRP	---	.06	.4-.7	.025	---	.05-.15	.02-.12	.05-.15
E60S-3	AO/CO_2	DCRP	---	.06-.15	.45-.7	.025	---	---	---	---
E70S-4	CO_2	DCRP	---	.07-.15	.65-.85	.025	---	---	---	---
E70S-5	CO_2	-----	---	.07-.19	.3-.6	.025	---	---	---	.05-.9
E70S-6	CO_2	DC	---	.07-.15	.8-1.15	.025	---	---	---	---
E70S-1B	CO_2	DCRP	---	.07-.12	.5-.8	.025	.15	---	---	---
				Emissive Wire						
E70U-1	AO	DCSP	---	.07-.15	.15-.35	.025	---	---	---	---
				Flux Cored Wire						
E60T-7	none	DCSP	1.5	---	.9	---	.5	---	---	1.8
E60T-8	none	DCRP	1.5	---	.9	---	.5	---	---	1.0
E70T-1	CO_2	DCRP	1.75	---	.9	---	.3	---	---	---
E70T-4	none	DCRP	1.5	---	.9	---	.5	---	---	1.8
E70T-5	none/CO_2	DCRP	1.5	---	.9	---	.3	---	---	---
E70T-6	none	DCRP	1.5	---	.9	---	.8	---	---	---

[1]AO = Argon + 1-5% O_2
CO_2 = Carbon dioxide
AO/CO_2 = Use either gas interchangeably

E70S-3 Primarily used for single pass welds; suitable for out-of-position welds with small diameter electrodes, using a short-arc transfer. Similar to E70S-1 except for higher silicon content.

E70S-4 Primarily used for CO_2 welding requiring slightly longer arc or for conditions requiring more deoxidants than E70S-1 or E70S-3.

E70S-5 This wire must be used with spray arc because of aluminum content. It is suitable for welding dirty or rusty surfaces.

E70S-6 Used for high speed, high current welding of rimmed steel. Used for sheet metal work where smooth beads are desired. Suitable for out-of-position welding by shortcircuiting transfer.

E70S-1B Used where x-ray quality welds are required on ordinary and hard-to-weld low carbon and alloy steels. The puddle solidifies quickly permitting out- of-position welding.

E70U-1 Weld with DCSP for higher deposition rates. The electrode gives a spatter-free weld with spray-arc transfer. This electrode can only be used with DCSP.

E60T-7 Welds made with this wire have low sensitivity to cracking.

E60T-8 Used for single-or multiple-pass welds in flat or horizontal position. Due to shallow penetration the weld deposits have low sensitivity to cracking.

E70T-1 To weld with some electrodes in this classification it is necessary that the joints be clean and free of oil, oxide and scale. These electrodes have a high deposition rate, low spatter loss and flat to convex bead configuration. The slag is easy to remove.

E70T-4 Used for single-or multiple-pass welds in flat or horizontal position. Due to shallow penetration, these weld deposits have a low sensitivity to cracking.

E70T-5 Used for flat, fillet or groove welds with or without shielding gas. Horizontal fillet welds can be made at lower deposition rates. This electrode may be used in situations where draft may affect gas flow. A shielding gas is not required but better quality welds are produced with CO_2 shielding. The metal transfer is globular with shallow penetration.

E70T-6 This electrode is similar to E70T-5 but is designed for use without shielding gas.

It may be a good idea to consult with your welding supplier and take advantage of their experience in working with other customers, and helping them select the proper electrode wire.

3. HOW IS THE EQUIPMENT SET UP?

Since the Mig welder is expensive equipment, the original setup should be done by the vendor or the dealer who sold the machine. It is a good idea to include a statement on the purchase agreement, "The vendor will set up, install, and demonstrate the machine at the time of delivery." If this is not done, you may receive a number of items of equipment that you do not recognize and inadequate or puzzling instructions for their assembly. This setup should include connecting the power input into the welding equipment, installing and adjusting the wire feeder and controls, connecting and aligning the wire feeder and gun cable assembly, attaching the gas cylinder, connecting the gas supply to the wire feeder and gun assembly, making power connectings to the wire feeder from the welding machine, and connecting the cooling water if the equipment is water cooled.

Be sure to file the instruction manual where it can be found when it is necessary to service the equipment, or order parts.

Shielding gas supply

Locate the gas cylinder so that when the regulator (flowmeter) is attached, it can be viewed by the operator. Chain or tie the cylinder in an upright position so that it cannot fall over.

Place the cylinder valve protecting cap where you can find it when you wish to exchange the cylinder. Stand to one side of the cylinder and open the cylinder valve slightly for just a second and then close it. The force of the excaping gas will clear the cylinder opening of dust or dirt that may have accumulated while the cylinder was in storage.

Support the pressure regulator or flow meter with your left hand while you tighten the connecting nut that mounts it on the cylinder. Do not exert too much pressure as the excessive force may

stretch the brass connecting nut. Do not force connections that do not fit. Do not use oil or plumbing compounds in connecting this shielding gas as these products tend to gum up the regulating equipment and contaminate the shielding gas.

Water supply

The heat of welding arc makes is necessary to cool some guns with water.

It is important that the cooling water be clean. If flakes of scale, rust, or other impurities restrict or block passages in the cooling system, this can cause damage to the equipment. For this reason, it is advisable to use a water strainer or filter on the water supply.

Check the manufacturer's recommendations and be sure that the water-supply pressure is not greater than the amount recommended for the welding gun ot torch. In general, if the pressure of the water supply is greater than 55 psi, a water regulator should be installed to prevent damage to the hose and equipment.

If the welder is located where the temperature drops below freezing, you should use portable tanks of recirculated coolant. Check the tank that contains the coolant and replace any that is lost. It is recommended that the tank be drained from time to time and refilled so that the circulating water is always clean.

Electrical equipment

Be sure the power-input cable is of the correct size with the proper number of conductors. Check your manual for the equipment and be sure that you have the correct current. Be sure the welding machine is properly grounded. Mount the shielding-gas cylinders so they are never grounded.

4. WHAT ARE THE STEPS IN MIG WELDING?

Safety precautions

You will need to follow all of the safety precautions that are followed for safe metal-arc welding.

Arc Rays

The welding is extremely hot and bright. It is important to protect your eyes from the direct rays of the arc. Choose the correct lens shade from the list below for MIG welding.

Lens Shade	Current Range
8	30 - 75
10	75 - 200
12	200 - 400
14	over 400

Most welders use a no. 9 lens working out of doors. When welding in a shop you may wish to use a No. 10 or 11.

Wear protective clothing to protect you from spatter of molten metal as well as the rays of the arc. In cases of prolonged exposure to radiation, it is recommended that you wear leather clothing, such as apron, sleeves or jacket. Where high shoes that

are close fitting. Be sure your trousers are cuffless. Wear clothing that is not soaked with oil or grease. Wear safety goggles to protect the eyes when grinding or chipping.

Eyeburn is caused by looking at the arc with your eyes unprotected. Never strike an arc, even for an instant, unless your eyes and those of others are protected with adequate eye protection equipment. Even the reflected light from a light colored wall will burn the eyes if they are exposed for too long. Because of the danger from eyeburn it is advisable to use paints that have low indices of ultraviolet reflection in MIG welding areas.

Electrical shock

The potential of shock is present in all electric-power circuits. This is true for both AC and DC as well as high and low voltage. The only safe procedure is to handle any electric circuit with caution and respect. You must remember that when the MIG welder is operating, the wire-feed mechanism is at welding potential. The current is transferred to the wire through the contact tube and the wire spool or reel must also be insulated from the welder frame. The open-circuit voltage is about 30 volts for MIG welding while it may be 90 volts for metal-arc welding.

One of the greatest sources of danger of shock to the operator is high humidity or dampness. The operator's clothing reduces the electrical resistance and increases the possibility of noticeable shock from any type of arc welding equipment. Gloves, aprons, sleeve protectors, jackets, and other clothing should be kept dry when welding is to be done.

Stand on a dry wooden mat or similar insulating material rather than on grounded metal. Do not weld in an area where the floor is wet. If the torch is water cooled, repair leaks before welding.

Check the welding gun to be sure it is in good condition. Do not put an energized welding gun under your arm at any time. Protect the gun from possible contact with other people. Do not place a hot welding gun into water to cool it. If the gun is water cooled, be sure water is flowing through it. This creates the possibility of shock hazard. Check all connections to the welding gun. If any are operating hot, you should inspect for a poor electrical connection. Place the welding gun in an insulated holder so that the wire is not touching the ground. Protect the hoses, cable, and gun from hot metal, grease, and open flame. Be sure the hose is not run over. Avoid tangles and kinks. Do not leave the cables where they can cause others to trip or fall.

Ventilation

The ventilation requirements for manual metal-arc welding are adequate for MIG welding. There should be at least 10,000 cubic feet of free air per operator if the ceiling is 16 ft. or higher. If the operator is in a confined space, the area should be adequately ventilated with forced air. There is no hazard from inhalation of inert gases or CO_2 gas in the normal welding area because the concetrations of these gases at distances greater than three or four inches from the smoke cone are insignificant.

Fire prevention

The fire safety hazard may be less with MIG welding because there is less spatter and the smaller particles do not tend to travel as far as those from metal-arc welding. Follow normal precautions concerning welding in the vicinity of flammable or combustible materials. Since you are able to weld a greater percentage of the time because there is no need to stop to replace electrodes, it is advisable to stop periodically to see that no fires have started in the welding area.

Cylinder safety

The compressed gas cylinders present you with another safety responsibility. Handle and store cylinders carefully. Secure cylinders to the welder or the wall before removing the valve protective cap, to install the regulators. Do not drop cylinders, use them as rollers, lift them with magnets, or strike an arc on them. Store empty cylinders in an upright position with the valves closed.

General safety

Some general safety recommendations include the following: Do not weld alone in compartments. Do not weld on closed tanks or containers, unless they have been adequately safeguarded by filling them with water, steam, inert gas, or other safeguarding means. Be sure the welder frame is grounded securely to earth, water pipe, or conduct system. Use cables and adequate ground clamps for return conductors. Do not use pipe lines, especially those carrying gas or flammable liquids for a ground return circuit. Be sure cable couplings and splice connections are fully insulated.

Welding procedure variables

One manufacturer recommends that you check certain "distinct level variables" that cannot be considered as controls. These variables include wire type which you should select, based on the type of base metal, joint design, surface condition, and service requirements of the final product. The other variables include wire size, shielding gas type, and gas flow rate. These can usually be taken from a table, like Table V.

Table V. Manual MIG Welding - Single Pass, Flat Position, Low Carbon Steel.

WELD SIZE	MATERIAL THICKNESS T		NO. OF PASSES	ELECTRODE SIZE	WELDING CONDITIONS D.C.R.P.		GAS FLOW	TRAVEL SPEED
INCH	GAGE	INCH		INCH	ARC VOLTS	AMPERES	CFH	IPM
	24	.025	1	.030	16-17	30-50	15-20	15-20
	22	.031	1	.030	15-17	40-60	15-20	18-22
	20	.037	1	.035	15-17	55-85	15-20	35-40
	18	.050	1	.035	17-19	80-100	15-20	35-40
	16	.062	1	.035	17-19	90-110	20-25	30-35
	14	.078	1	.035	18-20	110-130	20-25	25-30
1/8	1/8	.125	1	.035	19-21	140-160	20-25	20-25
1/8 *	1/8	.125	1	.045	20-23	180-200	20-25	27-32
3/16		.187	1	.035	19-21	140-160	20-25	14-19
3/16 *		.187	1	.045	20-23	180-200	20-25	18-22
1/4		.250	1	.035	19-21	140-160	20-25	10-15
1/4 *		.250	1	.045	20-23	180-200	20-25	12-16

The "primary adjustable variables" are used to control the welding process. They affect such things as penetration, bead width, bead height, arc stability, deposition rate, and weld soundness. These variables are arc voltage, welding current, and travel speed. You can refer to the table for these recommendations also. These items can be easily adjusted from the recommended levels until you have the desired performance.

The "secondary adjustable variables" are such things as stick-out, nozzle angle, and wire-feed speed. These variables are adjustable over a wide range but they are not so easy to employ as controls because they cannot be assigned exact values. They usually cause a change in a primary variable, which in turn causes the desired change in bead formation.

Stick-out is the tip-to-work distance (Fig. 15). This is the area where preheating of the filler metal occurs.

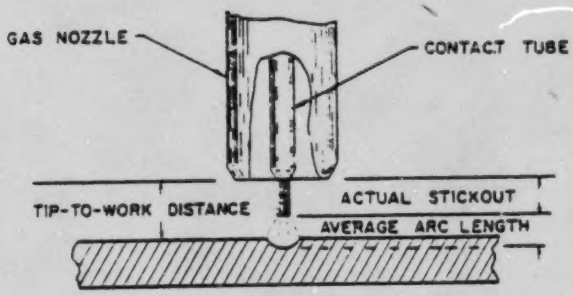


Fig. 15 The tip-to-work distance is called "stickout."

Nozzle angle refers to the position of the welding gun with respect to the joint. This position is described by two angles -- the transverse angle and the longitudinal angle (Fig. 16). The transverse angle refers to the relationship of the welding gun and weld joint in a plane perpendicular to the direction of travel. On fillet joints, the transverse angle is normally half of the included angle between the plates forming the joints. The longitudial angle refers to the angle between the center line of the welding gun and a line perpendicular to the axis of the weld. The longitudial angle may be either a trailing (pulling) or leading (pushing) angle (Fig. 17).

When a problem arises and it is necessary to change a weld's characteristics, the variables should be checked in order. Suppose your problem is penetration. Some of the distinct variables that could affect penetration are wire type, wire size, shielding gas, and flow rate. Next consider the primary adjustable variables (arc voltage, welding current, travel speed). In our example, the welding current should be changed. If the penetration change

is needed only for a short length of weld, then one of the secondary variables (stickout, nozzle angle, and wire-feed speed) could be changed. If the penetration needs to be decreased, increase the stickout and/or reduce the welding current (which would reduce penetration). If penetration needs to be increased for long passes and you are already operating at maximum current for the wire size, then you should go to the next largest wire size (distinct variable) to increase the welding current.

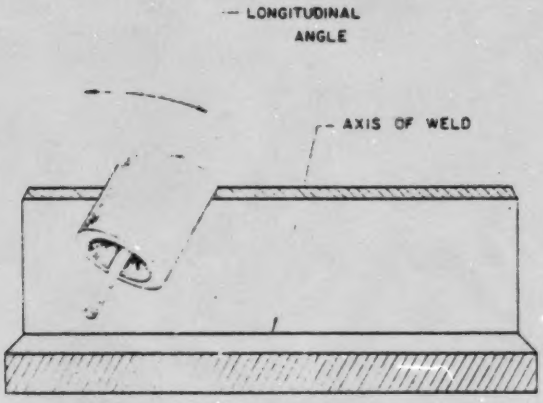


Fig. 16 The nozzle angle usually refers to the longitudinal angle.

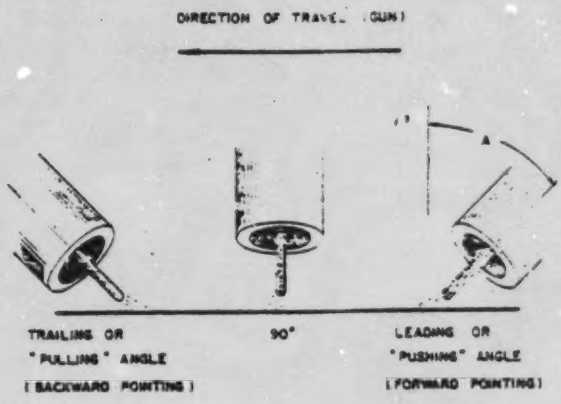


Fig. 17 The operator can affect the weld by using a leading or a trailing arc.

Table VI outlines the variable changes required to alter different weld characteristics. You should follow the order of the recommended adjustments as given in the table.

Table VI. Recommended Adjustments of Welding Variables

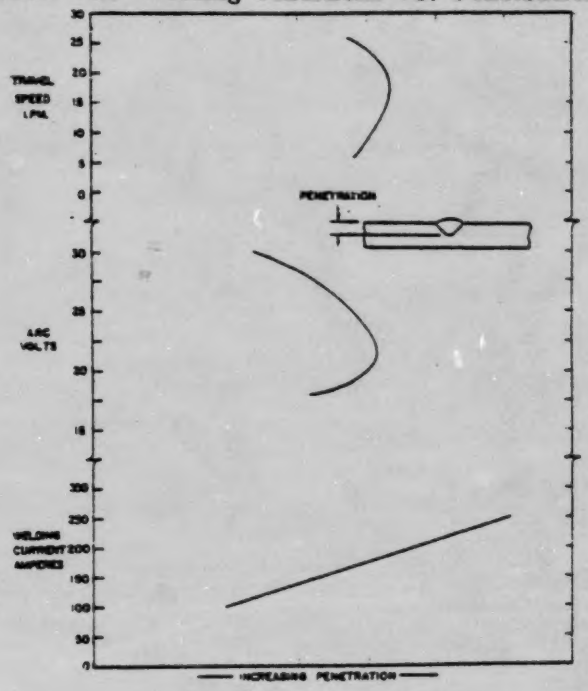
CHANGE REQUIRED \ WELDING VARIABLE		ARC VOLTAGE	WELDING CURRENT (SEE FOOTNOTE)	TRAVEL SPEED	NOZZLE ANGLE	STICK-OUT OR TIP-TO-WORK DISTANCE	WIRE SIZE	GAS TYPE
DEEPER PENETRATION			① INCREASE		③ TRAILING MAX. 25°	② DECREASE	⑤ SMALLER *	④ CO_2
SHALLOWER PENETRATION			① DECREASE		③ LEADING	② INCREASE	⑤ LARGER *	④ $AR+CO_2$ *
BEAD HEIGHT AND BEAD WIDTH	LARGER BEAD		① INCREASE	② DECREASE		③ INCREASE *		
	SMALLER BEAD		① DECREASE	② INCREASE		③ DECREASE *		
	HIGHER NARROWER BEAD	① DECREASE			② TRAILING	③ INCREASE		
	FLATTER WIDER BEAD	① INCREASE			② 90° OR LEADING	③ DECREASE		
FASTER DEPOSITION RATE			① INCREASE			② INCREASE *	③ SMALLER *	
SLOWER DEPOSITION RATE			① DECREASE			② DECREASE *	③ LARGER *	

FOOTNOTE SAME ADJUSTMENT IS REQUIRED FOR WIRE FEED SPEED.
KEY: ① FIRST CHOICE, ② SECOND CHOICE, ③ THIRD CHOICE, ④ FOURTH CHOICE, ⑤ FIFTH CHOICE.
* WHEN THESE VARIABLES ARE CHANGED, THE WIRE FEED SPEED MUST BE ADJUSTED SO THAT THE WELDING CURRENT REMAINS CONSTANT.
+ SEE DEPOSITION RATE SECTION OF WELDING VARIABLES SECTION.
# THIS CHANGE IS ESPECIALLY HELPFUL ON MATERIALS 20 GAGE AND SMALLER IN THICKNESS.

Penetration

Table VII shows the effect on each of the primary variables on penetration. These curves show that arc voltage and travel speed are not complete controls of penetration but that amperage has considerable effect on it.

Table VII. Welding Conditions Vs. Penetration



Stickout influences penetration through its effect on current (Table VIII). In semiautomatic (manual) operation, stickout can be adjusted by the operator during the welding process. It is an excellent means of compensating for joint variation. As the stickout is increased, the preheating of the wire increases. This in turn means that the power source need no longer furnish as much welding current to melt the wire at a given feed rate. Due to the self-regulating characteristic of the constant-voltage power source, the overall result will be a decrease in welding current output. As the current output decreases, the penetration decreases. If stickout decreases, the filler wire preheating effects will be reduced and the welding power source can furnish more current to burn off the wire at the required rate. This increase in welding current, leads to a proportionate increase in penetration. Table IX shows that you can use stickout to help bridge a wider gap between pieces of metal as when welding a poor fit-ap joint.

Nozzle angle can also have an effect on penetration (Table X). Maximum penetration is obtained from a trailing or pulling angle (a backward pointing) of approximately 25 degrees. If you change

Table VIII. Effect of Stickout on Current

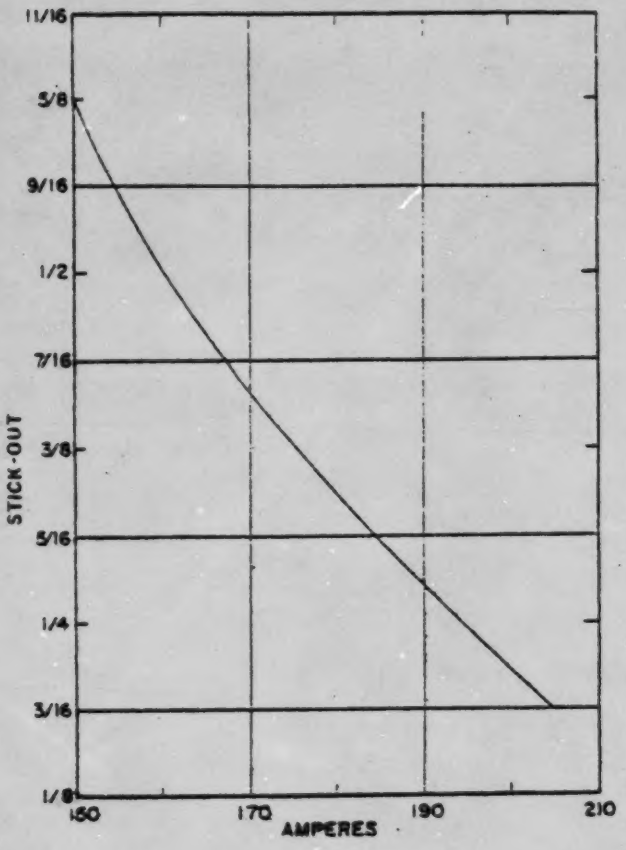


Table IX. Effect of Stickout on Penetration

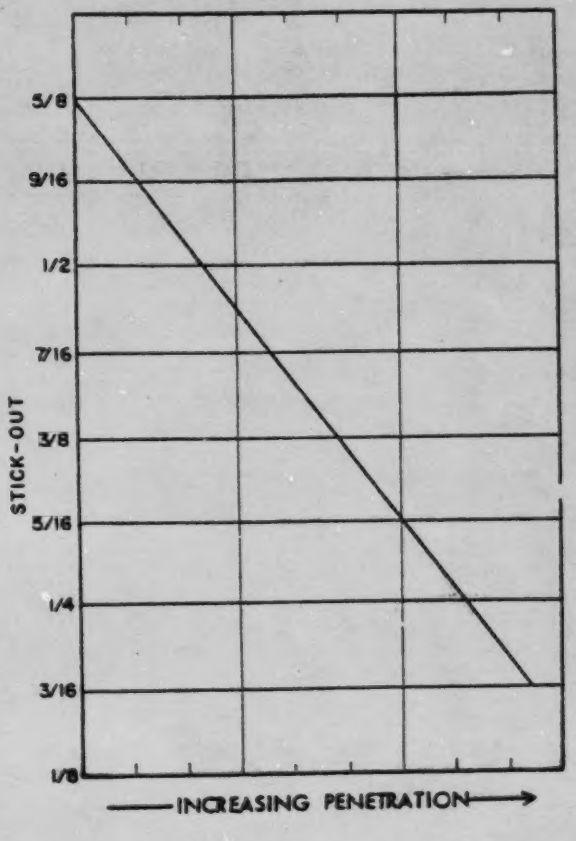
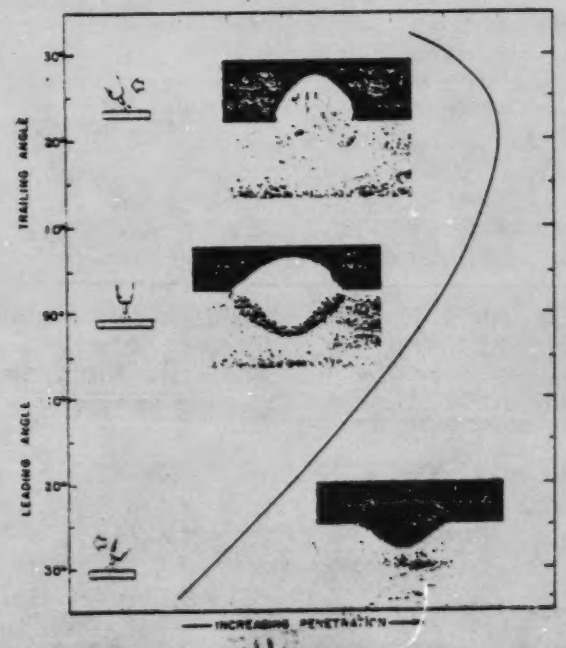


Table X. Effect of Nozzle Angle on Penetration



the nozzle angle from this optimum condition, penetration decreases. Notice in Table X that as you change the angle from a leading or pushing angle of 30 degrees to a trailing angle of 25 degrees, the penetration increases. A leading arc has the wire and arc pressing on cold metal which results in less penetration. It is not advisable to use a trailing angle greater than 25 degrees because cold lapping of the weld will occur. You can control penetration by changing the nozzle angle as you weld. You must remember that you will get maximum penetration with a trailing angle of 25 degrees and you should practice holding the gun at that angle.

Distinct variables that can affect bead contour are wire type and shielding gas. These variables have a moderate effect on steel. Stainless steel wires tend to produce a rather highly crowned bead. This tendency cannot be compensated for by changing primary or secondary variables.

The effect of the primary variables of voltage, current, and travel speed on bead height are shown in Table XI. The effect of these variables on bead width is shown in Table XII. Each of these variables will increase or decrease both bead height and width at the same time. If you decrease travel speed, both bead height and width will be increased. This illustrates that the overall effect of travel speed and welding current is to change the amount of filler metal being deposited per given length of joint. If you need more weld metal to fill a joint, decrease the travel speed and/or increase the welding current and wire speed on a CV welder.

Table XI. Welding Conditions Vs. Bead Height

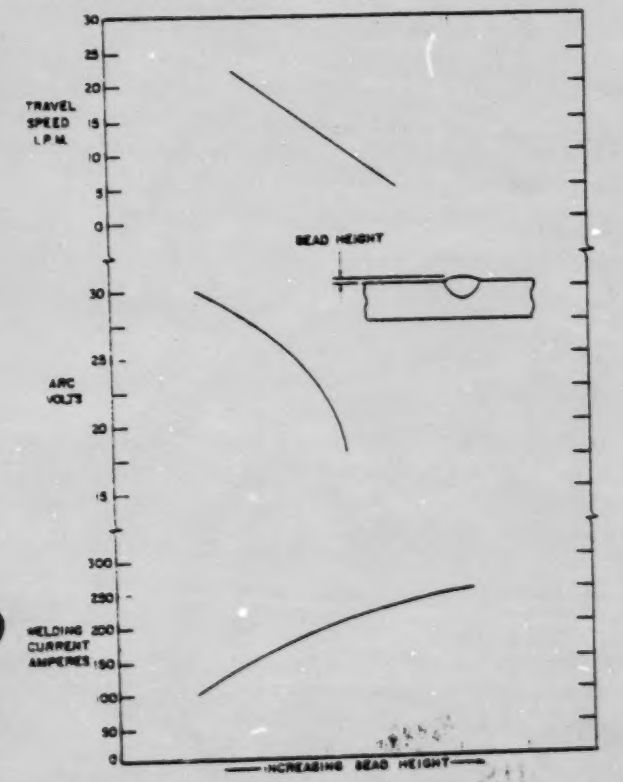
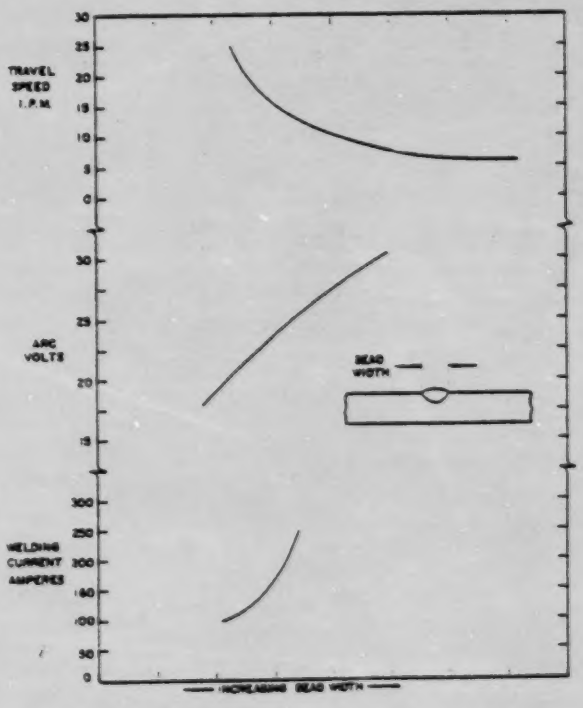


Table XII. Welding Conditions Vs. Bead Width



Bead height and width are important in avoiding weld defects, especially in multipass joints. If the bead height is too great it becomes difficult to fuse into underlying beads. If the bead width is too small, lack of fusion will occur at the side of the weld. To avoid these problems, keep the bead height to width relationship correct.

Arc voltage has the opposite effect on bead height from the effect on bead width. As the arc voltage increases, bead height decreases and bead width increases. This is comparable to metal-arc welding where a longer arc (higher voltage) tends to make a flatter weld that is wider. Arc voltage changes do not change the size of the bead but the contour or shape of the bead. You can use this control to flatten a bead that has too high a crown that may cause increased grinding or finishing. Of course, you must keep the arc voltage within the range required for arc stability.

Travel speed and welding current are the primary variables used to control bead size while arc voltage is used to control bead contour.

Of the secondary variables, nozzle angle is used to change bead height and width. A trailing nozzle angle tends to produce a high narrow bead. As the trailing is reduced, the bead height decreases and the width increases (Table X). Deposition rate is the amount of usable weld metal that can be deposited per hour by a welding process. It is best to consult the charts prepared by the manufacturer to determine this accurately. Factors such as burn-off rate, welding current, and stick-out affect the amount of metal deposited.

Welding procedure

Be sure the gun cable is connected to the proper welding terminal as designated by the manufacturer's instruction manual. DCRP is most widely used and this means that the welding wire is positive (+) and the workpiece is negative (-). The ground cable should be securely connected to the negative terminal, the cable uncoiled, and the ground clamp connected to the work.

Check that the wire type, wire size, and shielding gas are correct for the metal to be welded. The last of the distinct variables to check is the flow rate. This can be determined from the manufacturer's recommendations, such as Table V.

To set the flow rate, start the power source by turning on the switch or starting the engine. Set the wire feeder switch to the "on" position and set the wire-feed control to the "O" position. This prevents the wire from feeding while you are making other adjustments. Be sure the regulator handwheel is turned out if the shielding gas cylinder has a regulator or that the flowmeter is closed before opening the cylinder valve. Open the regulator or flowmeter slowly and at the same time squeeze the trigger and hold it open. Adjust the gas flow rate to the correct CFH rate according to the table, and release the trigger.

If the instructions in the table do not give specific amperage suggestions, you might find a convenient slide rule helpful that is provided by some suppliers. A good rule-of-thumb to follow is one

ampere for each .001" of metal thickness. This is a place to start.

When the welder is set on the proper amperage and inches of wire per minute, you are ready to set the voltage. The table should give a starting point, but if it does not, select any voltage that will give an arc and adjust it until it welds nicely for a given job.

Some beginning weldors will lower the voltage until the wire starts stubbing the plate and cannot maintain an arc. They record this voltage as read from the dial. Next, they raise the voltage until the arc starts to get quite long. At this point the puddle is very big and the arc is very sloppy. They record this voltage as read from the dial. They note the difference between these settings and divide the difference by two. By adding this amount to the lower setting they have a voltage setting in the middle of the arc range and have maximum leeway to manipulate the torch.

You cannot set voltage by the voltmeter on the welder. It will read zero when the machine is energized and not being used. It will read "open circuit voltage" (OCV) when the trigger of the gun is actuated but no arc is struck. It will read "arc voltage" when the arc is initiated, but you will need someone else to read this while you are operating the gun. The higher the voltage, the longer the arc and the wider the bead. Excessive voltage will cause spatter. A long arc may cause porosity because of the arc produced under an oxidizing atmosphere.

After the machine is set properly, there are several variables over which you have control.

Travel speed. This is just as important in MIG welding as in metal-arc welding. A recommended travel speed is found in the table. It is influenced by such things as stock thickness, joint design, cleanliness, fit-up, and position.

Stickout. The tip-to-work distance can affect weld penetration and weld shape. Short tip-to-work distances (3/8" or less) are desirable on small-wire, low-amperage applications. It is desirable to keep this distance as short as possible to get precision wire alignment over the joint and proper placement in the puddle.

Ground placement. Since arc blow is a problem with DC welding, the proper placement of the ground will improve the weld. If possible, attach the ground directly to the workpiece. Long, coiled cables act as reactors and set up stray magnetic fields that affect arc action. Weld away from the ground connection. The ionized gases that carry the arc are conductors and since conductors are surrounded by a magnetic field, these magnetic forces act like a draft to "blow" the arc to one side.

Shut down

After you have finished welding, turn the wire-feed speed control to zero; shut off the shielding gas-cylinder outlet valve; squeeze the welding gun trigger; hold down and bleed the gas lines when shielding gas is used; turn the regulator out to relieve the pressure on the diaphragm; turn off the wire feeder; and turn off the welder.

5. HOW ARE VARIOUS METALS WELDED?

Carbon steel

Most MIG welding is done on carbon steel. About 90 percent of all steel is plain carbon steel. Approximately 75 percent of the plain steel is rimmed, 15 percent is semikilled and 10 percent is fully killed.

There are two general categories of plain carbon steel -- killed and rimmed. Semikilled steel is intermediate between the two.

Killed steel. This is steel that has deoxidizers added, in the furnace, ladle, or mold, to cause it to solidify quietly without evolving gases. Killed steel has a smooth surface, is homogenous, and contains no blowholes.

Semikilled steel. This is an intermediate product to which deoxidizers have been added, but not sufficient quantities to entirely prevent the evolution of gases during solidification of the ingot.

Rimmed steel. This steel has not been deoxidized and its solidification is accompanied by the evolution of a large volume of gas. Rimmed steel has a rough surface and contains blowholes. It contains some iron and manganese oxides which are relatively unstable. It also contains sulphur as sulphide inclusions. When rimmed steel is melted, the iron and manganese oxides break down and give off oxygen. The oxygen in turn combines with the carbon and sulphur in the steel plate and in the welding wire. The resulting carbon and sulfur oxides pass off as gases. These gases cause porosity if trapped in the weld. The effect of the oxygen can be offset by the use of wires containing special deoxidizers.

Porosity control. Other ways to minimize porosity in carbon steel welding are:

1. Avoid excessive current densities -- change to a larger size wire if you think that the current is too high for the wire;
2. Check the welding speed -- welding speeds which are too high sometimes cause porosity;
3. Maintain a shielding flow of 40-50 cfh when using O-5 (95% argon, 5% oxygen) mixtures -- inadequate flow often results in porous seams;
4. Keep the wire centered in the gas pattern -- centering is important in carbon steel welding;
5. When welding from both sides of the plate, be sure that the root pass on the first side is deeply penetrated by the root pass on the second side.

Follow recommendation, such as Table XIII, when setting the welder for carbon steel. Weld away form the ground to reduce the effects of magnetic field.

Table XIII. MIG Welding Carbon Steel

Plate Thickness (in.)	Joint and Edge Preparation	Wire Diameter (in.)	Gas Flow (cfh)	DCRP (amps)	Voltage	Wire Feed Speed (ipm)	Welding Speed (ipm)	Passes
.035	Non-Positioned Fillet or Lap	.030	SIGMA O-5 ARGON MIXTURE (95% Argon + 5% O_2) C-25 Mixture (75% A + 25% CO_2) 10-15	55	16*	117	13	1
.047				65	17*	140	15	1
.063				85	17*	170	15	1
.078				105	18*	225	15	1
.100				110	18*	225	15	1
1/8				130	19*	300	16	1
1/8	Butt (Square Edge)	1/16	40-50	280	--	165	--	1
3/16	Butt (Square Edge)	1/16		375	--	265	--	2
3/16	Fillet or Lap	1/16		350	--	230	--	1
1/4	Double Vee Butt (60° included angle, no nose)	3/32		375 (1st pass) 430 (2nd pass)	27	83 (1st) 95 (2nd)	24	2
5/16	Double Vee Butt (60° included angle, no nose)			400 (1st pass) 420 (2nd pass)	28	87 (1st) 92 (2nd)	20	2
5/16	Non-positioned Fillet			400	27	87	16	1
1/2	Double Vee Butt (60° included angle, no nose)			400 (1st pass) 450 (2nd pass)	28	87 (1st) 100 (2nd)	14	2
1/2	Non-positioned Fillet			450	28	100	12	1
3/4	Double Vee Butt (90° included angle, no nose)			450 (all 4 passes)	29	100	12	4
3/4	Positioned Fillet			475	30	110	9	1
1	Fillet			450 (all 4 passes)	28	100	7	4

* Short Arc

Weld defects and remedies. If the appearance of your welds indicates porosity, cold lapping, burn through, lack of penetration, whiskers, wagon tracks, or excessive spatter, you may find the answer to these problems in the following guide.

SURFACE AND SUBSURFACE POROSITY

Probable Cause	Possible Remedy
I. Contamination by Air	
1. Too low a gas flow (does not displace all the air)	Gas flow is normally set at between 15 - and 20-cubic feet per hour (CFH).
2. Excessive gas flow (draws in the air)	
3. Gas shield blown away by wind or drafts	Provide shield or wind break to control drafts in welding area. Gas flow may be increased as much as 50 to 100% for welding outside.
4. Clogged or defective gas system	
a. Spatter on nozzle	Clean spatter from nozzle periodically. Check gas system for leaks and defective components.
b. Broken gas line	
c. Loose fittings	
d. Defective gas valve	
e. Frozen regulator	When drawing 25 cfh or over of CO_2 gas, cylinders should be paralleled or a heater should be used.

POROSITY IN CRATER AT END OF WELD

Contamination by Air	
5. Removal of gas shield by use of improper technique	Crater porosity can be avoided by holding the gun at its normal position at end of weld until wire feed and gas flow stop. Travel speed should not be so fast that molten does not solidify under the gas shield.
II. Contamination due to moisture in the shielding gas	Use welding grade or dry CO_2 gas (-40° F., dew point).
III. Foreign material on wire or workpiece (oil, dirt, rust, paint, etc.)	Work piece should be cleaned thoroughly before welding. Keep electrode wire covered and store in clean dry area.

Probable Cause	Possible Remedy
III. Foreign material on wire or workpiece (oil, dirt, rust, paint, etc.) (Continued)	If wire becomes too dirty to clean with an air hose, remove and scrap first one or two layers of wire.
IV. Improper welding conditions	
1. Excessive tip to work distance (stick-out)	Tip to work distance (stick-out) should be held between 1/4- and 3/8-inch.
2. Incorrect electrode or wire type	When welding mild steel, porosity can be reduced by selecting a more highly deoxidizing wire.
3. Welding over manual electrode tracks	Tack weld, using the solid-wire process, or if manual electrodes must be employed, use #6010 electrodes.

COLD LAP (Lack of Fusion)

V. Improper technique preventing welding arc from melting base metal	Direct the welding arc so that it covers all areas of the joint. Don't allow the puddle to do the fusing.
1. Improper directing of welding arc	Keep your wire at the leading edge of the puddle.
2. Weld metal flows into unwelded base metal due to excessively large puddle	Reduce the size of the puddle by either increasing travel speed or by reducing wire feed speed.

BURN THROUGH AND TOO MUCH PENETRATION

VI. Heat input too high in the weld area	Reduce your wire feed speed to obtain lower amperage.
	Increase travel speed.
1. Improper joint design or preparation	Maintain proper joint dimensions as closely as possible.
a. Excessive root opening	Compensation can be made for improper joint dimensions by increasing the stick-out (tip to work distance) to 1/2 - inch maximum distance or by weaving to prevent burn-through.
b. Root face too small	

LACK OF PENETRATION

VII. Heat input too low in the weld area	Increases your wire feed speed to obtain higher amperage.

Probable Cause	Possible Remedy
VII. Heat input too low in the weld area (Continued)	
	Reduce tip to work distance (stick-out) to obtain maximum current for wire feed setting.
1. Improper techniques	Maintain your arc on the leading edge of the puddle.
	The closer the arc is to the leading edge of the puddle, the more penetration you will get.

WHISKERS

VIII. Whiskers are caused by the electrode wire pushing past the front of the weld puddle leaving unmelted sections of wire on the root side of the joint.	Reduce your travel speed and use a weaving motion.
	Reduce welding current by increasing tip to work distance (stick-out) to 3/8-inch, or by decreasing your wire feed speed.
	DO NOT allow the wire to get ahead of the weld puddle.

WAGON TRACKS

IX. Wagon tracks are caused by entrapment of voids between passes	Arc voltage and travel speed should be kept sufficiently high to prevent the weld bead from becoming too high crowned.
Excessive bead contour and undercut normally lead to this defect.	Wagon tracks normally occur at the edges of the underlying weld bead; therefore, you must be careful, when welding over these areas, to be sure that the welding arc melts the underlying weld and base material.

EXCESSIVE SPATTER WHILE WELDING

X. Excessive shielding gas flow rates	Adjust gas flow rate.
XI. Excessive arc voltage	Reduce voltage at power source.
XII. Insufficient slope setting	Increase slope setting.
XIII. Tip recessed too far	Replace with longer tip.
XIV. Incorrect electrode wire	Use correct wire.

Aluminum

There are several things to keep in mind when welding aluminum.

While steel melts at approximately 2700° F., aluminum melts at about 1200° F. It is important that you watch aluminum closely to see that it does not melt and run away. Also, keep in mind that aluminum does not change color when it changes from a solid to a molten state.

The iron oxide or mill scale on steel melts at about 2470° F. The oxide coating on aluminum melts at 3700° F. These oxides must be removed from aluminum because the base metal will be molten long before the oxide coating will melt.

Aluminum conducts heat about five times as fast as steel. This means that a much higher, more concentrated, source of heat is needed for welding aluminum.

The procedures for welding aluminum are similar to the procedures for welding steel and the experience you have in welding steel will help you weld aluminum.

Just as there are steels with different analyses, so there are various kinds of aluminum. Aluminum really is a whole family of aluminum alloys. Most aluminum contains elements such as mangnesium, silicon, copper, zinc, or manganese. If you know the analysis or the series of aluminum you are working with, consult Table XIV and use the correct filler wire.

Table XIV. Filler Wire for MIG Welding Aluminum Alloys

Parent Metal Sheet, Plate or Tube	Filler Alloy
EC	EC/1100
1100	1100/4043
3003	1100/4043
3004	5356/5154/4043
5005	5356/5154/4043
5050	5356/5154/4043
5052	5183/5356/5154
5154	5183/5356/5154
5083	5183/5356
5086	5183/5356 (1)
6061	5356/4043 (2)
6062	5356/4043
6063	5356/4043 (2)

(1) Do not use 5154 filler with 5086 plate as transverse weld cracking may occur.
(2) If 4041 or 4043 is to be used as electrical conductor, and conductivity is the prime requisite, use 4043 filler metal. However, if strength and conductivity are both required, 5356 filler can be used and the weld reinforcement increased to compensate for the lower conductivity of 5356 filler metal.

Note: This table shows a good choice of filler metal for general purpose welding. Service exposure such as an immersion in fresh or salt water or exposure to special chemicals such as hydrogen peroxide, or sustained high temperature service (over 150 F) may require a different filler metal. Inquire at your nearest aluminum sales office for filler metal alloys to meet specific needs. Plate materials containing over 3 percent magnesium should not be used for prolonged service over 150 F. Weld metal which has not been coldworked by peening, forming, etc. is not susceptible to stress corrosion above 150 F.

To weld aluminum, remove the oil, grease, and oxide from the surface of the joint before you start. You can clean the base metal by using a weak acid, or an abrading tool. If possible use a clean

stainless steel wire brush to brush the oxide off the aluminum. A steel brush will incorporate metal in the aluminum and add additional problems in getting a good weld.

Use the correct shielding gas in the amounts recommended. If you use too small a flow of gas, there will be inadequate protection to the joint and poor welding will take place. A correct gas flow protects the work and excessive gas flow is simply wasteful and increases the cost of welding. Consult information like Table XV that shows the correct welding speed, amperage, voltage, gas flow, and electrode for the joint design that you are welding.

Table XV. MIG Short Arc Welding Aluminum

Plate Thickness (inches)	Type of Joint	Wire Diam. (inches)	Argon Flow (cfh)	Amperes (DCRP)	Voltage (Volts)	Approximate Wire Feed Speed (IPM)	Approximate Welding Speed (IPM)
0.040	Fillet or Tight Butt	0.030	30	40	15	240	20
0.050	Fillet or Tight Butt	0.030	15	50	15	290	15
0.063	Fillet or Tight Butt	0.030	15	60	15	340	15
0.093	Fillet or Tight Butt	0.030	15	90	15	410	15

For MIG welding of aluminum, you need a gun, a wire feeder supplied with aluminum filler wire, DC power supply, and shielding gas. Connect the gun to the positive terminal of the power supply and the negative terminal to the work piece. Aluminum should always be welded with reversed polarity as an aid in removing the oxide and producing a good weld.

Turn on the power and cooling water (if used) and adjust the shielding gas to the correct flow in cubic feet per hour. When you pull the gun trigger, this automatically opens the valves controlling the flow of gas and the cooling water to the gun. The electrode is energized and is ready to weld. Hold the gun at a slight angle and use a scratching motion to establish the arc. Hold the nozzle of the gun about 3/4 inch form the workpiece for 1/16" diameter wire. This will permit you to have good visibility and still provide good shielding gas protection for the weld. Always lean the gun about 25 degrees in the direction of travel (for a fillet weld tilt the gun about 45 degrees from the horizontal).

For maximum penetration and good quality, make a vertical weld starting at the bottom with the gun pointing upward. Because of high thermal conductivity, the aluminum weld bead solidifies faster than steel and this makes vertical and overhead welding easier.

Good welds in aluminum are easily done if the current, voltage, gas flow, filler wire, joint design are correct and the metal is clean.

Stainless steel

MIG welding has proven to be an economical, and satisfactory method of joining stainless steel. If you use the proper filler metal and welding procedures for the base metal, the mechanical, physical, and corrosion-resistant properties that you desire will be secured.

Stainless steel alloys. Iron is the main element of all stainless steels. To make it stainless; however, chromium must be present in the amount of 11.5% or more. One major type is composed of iron and chromium. Other elements are added to provide desirable properties. When more than 11.5% chromium is added to iron, a fine film of chromium oxide forms on the surfaces. This film acts as a barrier to further oxidation, rust, or corrosion. In other words, it gives the steel the stainless characteristics. There are about 16 types of stainless steels composed of iron and chromium and these are known as the 400 series or the "straight chrome" type. Within this series of "straight chrome" type, the amount of chromium ranges from 11.5 to 29%. All are highly magnetic.

The addition of nickel in the proper ratio results in a stainless series referred to as "chrome-nickel" types. These are the 300 series which include about 22 types of stainless steels. They all contain nickel and are nonmagnetic. The addition of nickel increases the corrosion resistance, ductility, electrical resistance, impact properties, and fatigue resistance. Within the 300 series, there are steels with a standard amount of carbon and steels with less than the standard. The reason for "extra low carbon" is that it reduces chromium carbide precipitation which in turn maximizes corrosion resistance. Another way to eliminate the chromium carbide precipitation is to add small amounts of titanium or columbium to stabilize the alloy. The nickel can range from 9 to 22%.

There are three basic classes of stainless steel which are grouped according to their metallurgical micro-structure. They are known as "austenitic", "martensitic", and "ferritic". The physical properties of these three classifications differ and do require different welding wires and procedures. The "austenitic" stainless steels are composed of both chromium and nickel. They are high in strength but ductile and are never magnetic. The 300 series stainless steels are all basically ausetenitic. Austenitic stainless steels should never be preheated and the interpass temperature should not be allowed to exceed 600° F. The "martensitic" stainless steels contain 11.5 to 17% chromium. They may become hard and brittle and usually require preheat and postheat when welding. The "ferritic" stainless steels contain 17 to 17% chromium, and are usually soft and ductile, but can become brittle when welded unless preheat and an appropriate procedure are used.

Electrode and shielding gas properties

Electrode selection is influenced by the corrosion resistance and strength properties required in the weld. Electrode composition for austenitic stainless steels in generally selected to closely match base metal composition and provide from four to eight percent delta ferrite in the weld to minimize the tendency for hot cracking. The resulting weld will generally exhibit excellent corosion resistance so long as the ratio of chromium to molybdenum

exceeds approximately nine.

Weld deposit composition is influenced by choice of shielding gas as well as type of electrode metal. Gases such as helium, argon, and helium-argon mixtures, are inert and do not contribute to the weld deposit chemistry. Helium, being less dense, provides less coverage per given flow and is affected more by moderate wind velocities. CO_2 gas and mixtures of CO_2- Argon provide adequate gas coverage and arc stability with economy. The disassociation of CO_2 gas into CO and O_2 contributes to a rise in deposited carbon and reduction in silicon, so extra-low carbon, high silicon wires are generally employed to assure adequate silicon content with minimum carbon content.

For general applications, 100% CO_2 gas with low carbon, high silicon, wire often provides adequate corrosion resistance. If corrosion requirements are critical either the 75A-25 CO_2 gas with low-carbon, high-silicon wire or 90 He-7.5 CO_2 gas with low carbon wire should be considered for all position welding. For all position welding, 100 CO_2 and 75A-25 CO_2 gases will generally provide smoothest operation and best arc control. Both of these gases are useful in welding thin material. The Argon-Oxygen mixtures such as 98A-2 O_2 provide higher deposition capabilities and better appearance for flat position welding.

Corrosion resistance is most affected by chromium content so it is very important that chromium content be maintained at a uniformly high level throughout the weld joint and heat affected zone. A common chromium depleting mechanism which can occur during welding is carbide precipitation. This occurs if the metal is heated in the range of 800 to 1400° F. for a period of time. The heat welding causes a heating effect in the area adjacent to the weld and in the weld metal itself which can cause carbide precipitation. To eliminate this problem, low carbon or stabilized base-metal alloys (321 or 347) should be specified if maximum as-welded corrosion resistance is required. Filler metals should also be of the low carbon or stabilized variety.

There are several modes of metal transfer available, one of which is the spray arc, which will provide maximum deposition rates in the flat position with relatively high currents for a given wire diameter. An argon-oxygen gas mixture promotes spray transfer. A shortcircuiting type of transfer is definitely preferred for out of position welding since better control of puddle fluidity can be accomplished. To attain this mode of transfer, lower currents and gas mixtures containing CO_2 gas are usually required.

Tables XVI, XVII should be used to select the optimum electrode wire and shielding gas combination for general use. The following considerations should be made:

1. Select a wire from a group designated in Table XVI for the base metal on which welding is to be done. Note the matching suggested gas types for this wire.

2. Select a gas having the required position capability from

Table XVII to match the wire selected.

Table XVI. Filler Metal Selection Guide

For Welding Base Metal Type	Use Shielding Gas Type	Use Wire Type
410, 430 (1) 431, 446	A-CO_2, CO_2 A-O_2, He-A-CO_2	308L, ML5M 308L, 309, 310
301, 302, 301 302, 304, 305	A-CO_2 A-O_2, He-A-CO_2	308L, ML5M 308L
304L	A-O_2, He-A-CO_2 A-O_2, He-A-CO_2, A-CO_2	304L 347
309	A-O_2, He-A-CO_2	309
310	A-O_2, He-A-CO_2	310
316	A-CO_2 A-O_2, He-A-CO_2	316L, ML5M 316L, 310
316L	A-O_2, He-A-CO_2	316L
321, 347, 348	A-O_2, He-A-CO_2, A-CO_2	347

(1) These materials require appropriate preheat and interpass temperature control prevent cracking in the heat affected zone. Filler metals are for use in the as-welded condition.

Table XVII. Guide for Selecting Shielding Gas

Trade Designation	Chemical Composition	Welding Position	Weld Deposit (1) Corrosion Resistance
[illegible]	75A - 25 CO_2	All	High
A1025	Ar - 7.5A - 2.5 CO_2	All	High
H2	99A - H_2	Flat	High
H5	95A - H_2	Flat	High
CO_2	100 CO_2	All	Good

(1) Assuming correct filler metal chemistry to match gas.

Welding procedures. Actual welding variables including current, voltage, travel speed, wire diameter, and recommended shielding gas rates are shown in Table XVIII. These procedures are included to furnish guidelines for the welder. Since austenitic grades (300 series) are generally more popular than ferritic and martensitic grades (400 series), the procedures listed are aimed primarily at welding austenitic alloys. The welding variables shown for sheet metal are for flat-position welding while the footnote explains modifications to the conditions for out-of-position welding. Welds are to be continuous single-pass or multiple pass with a stringer-bead technique. Weaving techniques if used should be kept to a minimum width. The gun-to-work distance or stickout is to be maintained relatively constant during welding.

Table XVIII. MIG Welding Stainless Steel

Material Thickness, In.	Electrode Diameter, In.	Current Amps (1)	Arc Voltage (1)	Gas Flow-CFH	Travel Speed-IPM
1/16	.035	90-100	18 - 19	15 - 20	15 - 30
3/32	.035	125-130	17 - 21	15 - 20	20 - 30
1/8	.035	130-150	18 - 24	15 - 20	20 - 25
3/32	.045	190-250	22 - 26	15 - 20	25 - 30
1/4	.045	225-300	22 - 30	15 - 20	25 - 30

(1) Values are given for flat position. Reduce current 10 to 20 for vertical and overhead positions. Reduce voltage proportionately.

Gas flows shown in Table XVIII are typical for indoor shielding conditions. Flows should be increased 50 to 100% for welding in the open. Protective wind shields should be used around outdoor welding areas if wind velocity is higher than 5 to 6 mph.

Weld backing. Copper backup strips are helpful for welding stainless steel up to 1/16-inch thick. Back up is also needed when welding 1/4-inch or thicker from only one side. No air should be permitted to reach the back side of the weld while the puddle is solidifying. Oxygen and nitrogen will weaken molten and cooling stainless steel. If the jig or fixture members permit an appreciable amount of air to contact the underside of the weld, argon backup gas should be used.

6. WHAT IS FLUX-COATED WIRE WELDING?

The MIG process may also use a flux-cored consumable electrode, fed continuously into the arc puddle. This electrode is really an "inside-out" electrode, the flux is on the inside instead of the outside as with a stick electrode (Fig. 18). The welding arc and puddle are shielded from the surrounding atmosphere by CO_2 gas. The process may be applied manually and automatically.

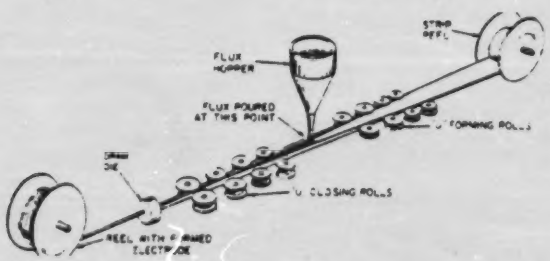


Fig. 18 The tubular cored electrode wires are manufactured in this manner. Care must be used to be sure the flux is continuous in the electrode.

The core materials (Fig. 19) inside the electrode perform several functions: (1) provide a protective slag covering for the deposited weld metal, (2) deoxidize and cleanse the weld metal, (3) provide alloying materials, and (4) help stabilize the arc.

Advantages

This welding process has several advantages over metal-arc, submerged arc and solid wire MIG welding. The welds have outstanding appearance. Most steels can be welded, in a wide range of thicknesses with an efficient operating factor and high deposition rate. It has high travel speed and is easy to use.

Appearance. The appearance of flux-coated deposit is similar to that of iron powder stick electrodes. The stable arc insures smooth welds of good contour with a minimum of spatter. You can make fillet welds with equal legs and the toe of the fillet will

blend in smoothly into the base metal without objectionable undercutting.

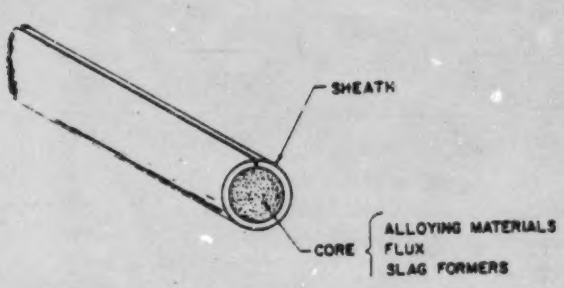


Fig. 19 The sheath amounts to 80 - 85% of the weight of the electrode and the core material represents 15 - 20%.

Thickness range. With this process you can weld most steels in a wide range of thicknesses from 1/8 inch to 2 inches and thicker. The manufacturers have developed cored wires for mild steels, low-carbon steels, low-alloy high-strength steels, and medium carbon steels.

Operator factor. Your time is saved by this process since it is not necessary to stop to change electrodes as with submerged arc welding. There is only a small amount of slag produced and it is easily removed. The production per operator may be almost double that of metal-arc welding with stick electrodes. This increased productivity is especially important in view of high labor costs.

Deposition rate. The amount of weld metal that you can deposit is greater than with coated electrodes. For the same application, you will set the welder at 250 to 300 more amperes than for metal-arc welding. This current density (amperes per square inch of cross section of electrode) is as much as 600 per cent higher than for coated electrodes. This high current density produces greater heating of the wire which contributes to a higher melt-off in the arc. As with other MIG welding, there are no stub ends of electrodes to throw away which also increases deposition efficiency.

Travel speed. Your productivity is also increased because large-size single-pass fillets can be made at comparatively higher travel speed. You can make a horizontal fillet up to 3/8" and flat fillets up to 5/8" in one pass. The higher travel speed results in less distortion.

Use. See you can see the arc, you have complete control over the weld puddle. You can follow the joint with your eye to make sure the joint is filled. The equipment automatically controls the arc length. You can devote your attention to directing the weld metal and to maintaining the correct travel speed. As mentioned

before, one control sets the voltage and another sets the wire feed speed and amperage. Once you have the equipment set up, there is no further need to re-adjust the controls. The welding gun weighs approximately the same as an electrode holder. The scavenging elements in the core permit you to weld over mill scale and light rust without sand blasting the base metal prior to welding.

Performance

If a problem arises and you wish to change the characteristics of the weld, you can refer to Table VI. The recommendations are the same for flux-cored wire except that you should disregard the column on gas type.

Porosity. The probable cause of this defect is contamination by the atmosphere, moisture, dirt, oil, etc. This may be the result of: (1) Shielding gas flow is too low or not displacing all of the air in the weld. You may correct this by increasing the gas flow. Be sure the gas shield is not being blown away, so use a wind shield to shield the arc area. Check the gas system and be sure that spatter is not clogging the nozzle, and that the nozzle is not too far from the work. If you move the nozzle closer to the work you will improve the shielding. Another cause of porosity is (2) moisture in the shielding gas. Be sure that you are using dry welding grade of CO_2 gas. Another cause of porosity is (3) foreign material (oil, dirt, rust, paint, etc.) on the surface of the base metal or electrode wire. Be sure that you are not welding over a tack weld made with stick electrodes that is not thouroughly cleaned.

Crater porosity. The principal cause of this defect is that you are removing the gun and gas shielding before the crater has solidified. Hold the gun in the normal position at the end of the weld until the gas flow stops.

Burn through. If you are burning through or having excessive penetration the problem can be remedied by reducing the wire feed speed to get a lower amperage.

Slag inclusions. This defect and the lack of fusion is caused by poor cleaning of the previous weld and inadequate heat. You can correct this problem with proper cleaning and increasing the heat so that subsequent passes are completely fused.

Undercutting. This problem is usually caused by: (1) improper movement of gun, (2) travel speed too high, or (3) voltage settings too high. Moving the gun from side-to-side with a weaving motion will help eliminate undercutting. Reducing the voltage setting will avoid undercutting the weld.

Cracking. This problem can be eliminated by pre-heating and post-heating. Occasionally this is caused by depositing small high beads on thick parts. Welding with a larger bead will sometimes eliminate this problem.

Incorrect fillets. If the wire is too far away from the vertical leg, the weld metal will not wash up properly.

7. WHAT MAINTENANCE IS NEEDED?

One of the reasons for MIG welding has been gaining in popularity has been the increased productivity made possible through this welding process. The capital investment in a typical piece of equipment is approximately ten times what it would be for a manual metal-arc welder. This equipment must be kept in excellent operating condition at all times for this high-capital investment to pay off. The most common cause of down time is the wire-feed mechanism. It is important to schedule maintenance of the wire-feed system to maintain satisfactory operating condition. The wire-feed system consists of the following components: a constant-speed-wire-drive motor, a wire-spool holder, straightening rolls, a wire-feed cable, and a welding gun that contains the contact tube inside the nozzle.

Wire supply

The spool of wire is placed on the spindle. The wire is threaded through the straightening device and into the wire-feed rolls where it is pushed through the contact tube at the nozzle, and into the arc and weld pool. The function of the wire-drive mechanism is to move the wire through this cable into the shielding gas around the weld pool. The wire is confined laterally so it can only move in the desired direction. If the driving motor has adequate power, the wire will move smoothly from the spool to the gun.

If you are alert to the operation of your welder, you will notice signals indicating that something is wrong. This means that you are about to have wire-feeding failures. An alert operator will notice intermittent feeding and will begin a systematic examination of the equipment to determine the source of trouble.

Since the wire spool is the source of wire, check how the wire is wrapped on the spool or coil. It should be wrapped smugly. If it is loose and loops have slipped down over the wire as it is drawn off the spool, the effect is the same as pulling the wire through a knot. This situation is more likely to occur if the spool is mounted horizontally or if the friction device allows the spool to coast when the arc is stopped.

Keep just enough pressure on the wire spool so it does not coast ahead of the wire feeder. If the pressure is too great, the wire will be drawn into the center of the spool and may cause kinking problems.

You may also wish to check the direction of the wire straightening device through which the wire is threaded before it goes to the wire-feed rolls.

Straightening rolls

As the wire is wound on a spool, it develops a "cast" or tendency to coil. You have noticed this as a piece of wire is taken off the spool and allowed to go free, it tends to reform itself as a sort of coil spring. This tendency to form back into the direction into which it was wound on the roll is referred to as the "Cast". Only a slight amount of straightening is necessary to remove this "cast" from the wire and excessive bending will give

it an opposite "cast". This increases the load on the drive motor and may cause it to overheat.

Align the wire guide so the wire feeds into the rolls in the proper location. If the wire approaches the rolls at an angle, it will tend to climb out of the groove. When this happens the rolls separate and this loosens the tension on the wire and allows it to slip. Use a straight drill rod to align the wire guide with the feed rolls.

Be sure the drive-roll clamping pressure is correct. If the pressure is too heavy, it will flatten the wire to the point it will not go through the contact tube at the end of the cable in the gun. If the pressure if too light, it will allow the wire-feed mechanism to slip.

The wire enters the inlet guide from the drive rolls. Perhaps the most critical link in the entire system is the point where the wire leaves the drive roll, and enters the inlet guide to the wire-feed cable. Here the wire is unsupported and is subjected to the maximum thrust. If it is adjustable, make sure that the various parts are in perfect alignment. If the inlet guide is misaligned or offset, the wire must go through a reversed bend in order to travel from the feed rolls to the inlet guide. The slightest restriction on the wire will cause it to buckle laterally where the wire is unsupported. The subsequent accumulation of wire next to the inlet guide has been aptly referred to as a "bird's nest". This happens most often when small wires are pushed because they did not have the strength or stiffness to withstand the push of the drive motor.

"Bird nesting" can be held to a minimum by making sure that the inlet guide of the wire-feed cable is moved as closely as possible to the rollers. In fact, it may be so close to the rollers that it almost touches them.

Check the wire-feed cable to be sure that it is clean and free of kinks. Most of the steel welding wires are coated with a thin layer of copper. This copper layer tends to flake off as it passes through the drive. Some of these loose flakes will lodge inside the wire feed cable. These copper flakes accumulate and jam the welding wire so tightly in the cable that it may be impossible to move it.

Clean the cable by removing the wire and placing an air hose nozzle at the end of the cable where the contact tube screws on to it. Blow out the cable until the the chips stop coming. It is a good practice to blow out the cable every time a new spool of wire is installed. You may find it necessary to clean out the cable on your welder more often than this.

Check with the manufacturer's instructions concerning the use of lubricants. Some lubricants can combine with the oxides on the welding wire and cause a gum to form inside the cable.

Be sure the wire-feed cable and liner are the correct ones recommended for the wire. If the cable is too small, there will be excessive friction when the cable is bent. Too large a cable will allow the wire to deflect inside and perhaps collapse. A liner that is too long will pinch the wire where it presses against the

contact tube.

Pay particular attention to the contact tubes. The contact tubes are usually made of copper alloy. If the contact tube is oversized or worn, it will allow the wire to wobble. This will result in poor current transfer. Arcing in the tube is also likely to occur which can result in "burn back". It is usually not advisable to try to clean out the contact tube with small drills or acetylene tip reamers. These simply add to the problem because the bore of the contact tube is enlarged. "Burn backs" are usually caused by an arc inside the contact tube. This makes the wire stick and the open-circuit voltage will burn the wire back to the tube.

Testing the wire-feed system

The key to the wire-feed system is the ease of wire-feed movement. When the drive-roll clamp pressure is released, and the cable is laid out relatively straight, the wire should be free to move in either direction, without much effort. One manufacturer recommends this procedure for adjusting the wire feeder. Loosen the pressure adjusting screws. Pinch the wire between the thumb and forefinger of a canvas gloved hand as tightly as possible. Operate the "inch" switch. Gradually tighten the pressure adjusting screw until there is slight slippage. In this way the drive rolls will slip over the wire if it is stopped in the contact tube, etc.

One of the functions of the gun is to transfer the electric current to the wire, preferably through the contact tube. The other function is to guide the gas shield around the weld zone so as to exclude the atmosphere which would cause porosity in the completed weld.

Nozzles

The spatter build-up on the outside of the tip and the inner and outer surfaces of the nozzle must be cleaned away occasionally. This spatter prvents the shielding gas from making an envelope around the weld. If the spatter builds up thick enough inside the nozzle, it can actually bridge the gap between the contact tube and the nozzle and make an electrical connection. If you should accidentally touch the nozzle to a grounded surface, there will be an arc struck and the nozzle will be ruined. If a portion of the nozzle is burned away, the protection of the shielding gas envelope around the weld will be affected. Use a soft wood paddle such as a craft stick to remove this spatter from the end of the nozzle. Do not clean guns by tapping or pounding the nozzle on some solid object. The gun nozzles can be easily bent. This will distort the gas pattern. If the threads are damaged it will make it difficult to remove the nozzle to replace the contact tube.

Some manufacturers recommend the use of anti-spatter compound while others do not. These products are available in pressurized containers or as paste in cans.

Gas leaks

The weld pool must be protected from the atmosphere by the shielding gas. It is the function of the gun to control direct flow of the shielded gas. There is a leak in the gas system if the proper amount of gas will not be delivered to the welding area.

In your systematic examination for a gas leak, begin at the cylinder. Open the cylinder valve fully and check for leaks around the valve stem. Use soapy water and brush to check the connection between the cylinder and the regulator where the union nut is screwed onto the cylinder. Using a solution of soapy water (grease-free soap), test for leaks at the following locations: argon cylinder valve stem, regulator inlet connection, hose connection at the regulator outlet, connection to the valve, and connection from the valve to the torch.

Always be sure the flowmeter valve is fingertight before the cylinder is opened or the ball may fly up and break the flowmeter tube.

Wire-feeder problems

If you have problems with your wire feeder, you may find the following list of possible remedies useful.

PROBLEM	PROBABLE CAUSE	REMEDY OR CHECK
Wire-feed motor does not operate and pilot light not on.	Fuse blown (if neither feeder operates)	Replace fuse.
	Nor power to wire feeder	Check position of power toggle switch.
		Check 115V input power cable for connections at both the wire feeder and the power source.
		Check source of 115V power for correct voltage.
Wire-feed motor does not operate and pilot light is on.	Control relay not operating	Check control cable connection from gun wire to feeder.
		Check gun switch (see gun manual).
	Control relay operates but contacts not closing circuit	Clean relay contacts with fine file or OO sandpaper.
	Auxiliary contacts in welding power source not operating	Check auxiliary contacts on secondary contractor in welding power source. They must close when gun switch is closed.
		Check control cable connections between wire feeder and welding power source.
Wire-feed motor operates but wire does not feed.	Too little pressure on wire feed rolls	Increase the pressure adjustments on the wire-feed roll pressure plate.
	Incorrect wire feed rolls	Check size stamped on wire-feed rolls per table.

PROBLEM	PROBABLE CAUSE	REMEDY OR CHECK
	Wire spool or reel brake pressure too great	Decrease the drag on the wire spool.
	Restriction in the gun and cable assembly.	Examine cable, gun, and current contact tip for damage and correct size contact tip and cable linder, if used.
Wire wraps around the wire feed rolls.	Too much feed roll pressure	Decrease the pressure adjustment on the wire-feed roll pressure plate.
	Center guide or output guide not correctly aligned.	Realign center guide and output guide.
	Incorrect cable liner or current contact tip.	See instruction manual for correct size.
No speed control.	Broken or loose wires in wire-feed control circuit	Correct by checking all connections and making repairs as needed.
	Variable transformer winding is broken (wire speed control)	Replace the variable transformer.
	Knob loose on variable transformer	Tighten knob.
Wire feeds but no gas flows.	Failure of gas-valve solenoid	Replace.
	Loose or broken wires to gas-valve solenoid	Check all connections, repair as needed or replace valve coil.
	Gas-cylinder valve not open or flow meter not adjusted	Turn on gas valve at tank and adjust flow meter.
	Gas cylinder empty	Replace.
	Restriction in gas line	Check gas hose between flow meter and wire feeder, and gas hose in gun and cable assembly.

PROBLEM	PROBABLE CAUSE	REMEDY OR CHECK
Welding current not stable	Wire slipping in drive rolls	Readjust pressure on wire feed-roll pressure plate to eliminate wire slippage.
	Center guide or output guide alignment not correct.	Realign.
	Restriction in gun cable or gun	Consult instruction manual.
	Wrong size liner or current contact tip	Consult instruction manual.
	Loose connections on the welding or ground cable	Check all connections, tighten if necessary.

Welder Problems

If your welder is not operating satisfactorily, you may find the following list helpful for a three-phase welder with variable slope.

TROUBLE	CAUSE	REMEDY
Welder will not start	Power switch OFF	Place power switch in ON position.
	Power lines dead	Check voltage.
	Broken power lead	Repair.
	Wrong line voltage	Check power supply.
	Incorrect input power connections at welder	Check connections against wiring diagram.
	Blown fuses	Replace.
	Overload relay has tripped	Resets automatically after a few seconds.
	Open curcuit to power switch control transformer	Repair. Check for broken wire or loose connections at terminals.
	Fuse on front panel blown	Find cause, 115 volt receptacle may be overloaded. Replace fuse.

TROUBLE	CAUSE	REMEDY
	Overload relay failed	Check for failed overload heater elements and micro switch. Replace defective parts.
	Overload relay trip bar binding	Loosen screws at side of trip bar.
Line contactor fails to close	Defective NVR coil	Replace.
	Mechanical obstruction on starting switch.	Remove.
	Broken leads at line contactor	Repair.
	Open circuit between time delay relay and control transformer	Check for broken wires and loose connections and repair.
	Open circuit between time delay relay contacts and NVR coil contactor	Check for broken wires and loose connections and replace.
	Time delay relay failed. (Unit will operate if set to instantaneous contactor opening)	Replace.
	Gun switch cable not plugged into contactor control receptacle	Plug in for remote operation of contactor.
	Overload relay tripped, welder overloaded.	Check with ammeter if welder is overloaded and reduce load if necessary.
Contactor chatters	Line leads too small	Use larger leads.
	Low line voltage	Check power source voltage.
Contactor hums	Dirt on contact faces of line switch magnet	Clean faces of magnet.
	Improper alignment of stationary and movable magnet yolks on starting switch	Correct alignment.

TROUBLE	CAUSE	REMEDY
Contactor operates and blows fuse	Wrong line voltage	Check nameplate of welder for line voltage to use, check line voltage.
	Links on line contactor incorrectly connected	Check wiring diagrams for line positions, connect links correctly.
	Fuse too small	Install proper size fuses.
	Diode failed	Replace. See note in maintenance section.
	Short circuit in primary connections	Remove short circuit.
	Transformer failed	Repair or replace.
Welder delivers welding current but soon shuts down	Welder overloaded	Reduce load, overload can be carried only for a short time.
	Duty cycle too high	Do not operate continually at overload currents.
	Power leads too long or too small in cross section	Replace with larger diameter cable.
	Ambient temperature too high	Operate at reduced loads when temperature exceeds 100° F.
	Ventilation blocked	Check air intake and exhaust openings to be unobstructed.
	Fan not operating	Check bearings, disconnet leads and apply motor nameplate voltage to check.
Contractor operates but welder will not deliver welding current	No ground connections at work	Make connections.

TROUBLE	CAUSE	REMEDY
Contractor operates but welder will not deliver welding current (Continued)	Welding cables not connected	Make connections.
	Transformer winding open	Have transformer repaired.
	Transformer secondary failed	Have transformer repaired.
	Diode failed	Replace. See note in maintenance section.
	Voltage switch improperly set	Set to arrow.
Fine voltage dial does not control welding voltage	Variac burned out	Replace variac.
	Control rectifier failed.	Replace rectifier.
	Loose connections in voltage control circuit	Check connections at control rectifier, terminal strips, control coils, local-remote switch, voltage control receptacles and variac.
	Control coil failure	Repair reactor.
	Hot start-soft start switch thrown to SOFT START at welding currents below 200 amperes	Throw to HOT START.
Fan not operating (also see causes and remedies under "Welder will not start")	Motor failed	Replace or repair.
	Broken lead or connection to fan motor	Repair wiring.
	Blown fuse on front panel of welder	Replace, 115 volt receptacle may be overloaded.

TROUBLE	CAUSE	REMEDY
Operator gets shock when welder is touched	Case of welder not grounded	Ground welder case.
Operator gets shock when ground cable, work or work table is touched	Work table and work not grounded	Grounded work and work table to plant ground.
Abnormal current fluctuation, voltage nearly constant	Irregular wire feed speed	See welding head manual.
	Inadequate sheilding or arc by flux or gas	Increase shielding by trial and error. See welding head manual.
	Wire feed rate too slow	Increase wire feed. See wire burn-off rate charts.
	Too much shielding gas	Decrease by trial and error. See welding head manual.
	Loose cable connections	Check for overheated connections and tighten.
	Welding current tip on wire feeder makes poor contact with electrode	Check current tip hole size and replace with proper size tip.
Contactor fails to open	Contactor contacts sticking	See maintenance section of instruction book.
	Time delay relay failed	Replace.
Undercutting only during first portion of weld operating at fast travel speeds	Hot start-soft start switch thrown to HOT START	Throw to SOFT START.
Trouble starting arc when Micro-wire welding (also see wire feeder instruction book)	Hot start-soft start switch thrown to SOFT START	Throw to HOT START.

TROUBLE	CAUSE	REMEDY
Wire freezes in puddle when switch is released	Delayed-instant contactor opening switch set to INSTANT	Set to DELAYED.
Burn back while welding aluminum	Delay-instant contactor switch set to DELAYED	Set to INSTANT.

Your MIG welder is an expensive welder that will allow you to increase your productive capacity if it is kept operating. Maintain it properly and it will give you many hours of trouble-free service. Keep your welders in good condition and operators will not abuse them.

Provide a convenient place to store the ground cable and the welding guns.

AGRICULTURAL MECHANICS

Topic 2: Oxyacetylene Cutting and Welding

Suggested Procedures and Activities: The use of filmstrips, slides, and transparencies can be helpful when discussing the technical information.

Oxyacetylene cutting is a process used to separate metal by heating it to a kindling temperature (burning temperature) between 1,400 and 1,800 degrees F., then oxidizing and blowing the metal from the cut with a stream of oxygen.

Oxyacetylene welding is the joining of two pieces of metal together by heating them to the melting point. The heat to be provided by the combustion of a gas mixture, oxygen and acetylene.

1. The Major Functions of Oxyacetylene Heat Are:

   a. Metal is joined by the fusion process. The heated (melted) portions fuse together forming a weld. The process can be accomplished with or without the use of a welding rod.

   b. The joining of metals or metal by adding bronze as a filler is known as brazing. Base metal is heated to a temperature that will cause the bronze to stick and bond the metals together.

   c. Soft and hard solders (lead and silver alloys) are the filler materials in soldering. The base material is heated to a temperature that will cause the solder to stick.

   d. Oxyacetylene flame is used to bend, shape, preheat, post-heat, and temper metals. Heating of metals is one of the most important functions of the oxyacetylene flame.

   e. The oxyacetylene flame is also important in separating metals. The metal oxidizes after a kindling temperature is attained and pure oxygen is applied to it. This practice is known as cutting or burning.

2. Description of Oxygen and Acetylene

   a. Oxygen (O_2) is one of our most abundant gases. One-fifth of the air breathed is oxygen. It is colorless, odorless, and tasteless and is heavier than air. Oxygen is considered a supporter of combustion. It is produced commercially by causing air to liquify and using fractional distillation to recover the oxygen.

   b. Acetylene (C_2H_2) has a distinct odor and like oxygen is colorless. When calcium carbide and water are mixed a hydrocarbon is formed. The equation is $CaC_2 + 2H_2O = C_2H_2 + Ca(OH)_2$ acetylene and calcium hydroxide. Acetylene burns in both the primary combustion area (cone of the flame) and the secondary combustion area (envelope of the flame). The end of the inner cone may produce a neutral flame temperature from about 5,400 to 6,300 degrees F. The temperature is raised by adding oxygen.

3. Oxyacetylene Safety Practices

Transparency No. 1

Safety cannot be "Bought"; it must be "Practiced", this is especially true when working with oxygen and acetylene gases. The most common hazards found in welding are burns caused by heated metal and welding dust, and injuries due to toxic gases or fumes. The weldor should be thoroughly informed regarding all safety practices, including the use of oxygen and acetylene for both welding and cutting.

a. Personal safety rules to observe are:

(1) Be neat and clean about work and work areas. Keep equipment clean and in good operating condition.

(2) Never use oxygen as air pressure for cleaning or in pneumatic tools. Oxygen must not be used in oil preheating burners, to blow out lines, to create pressure in containers, or any place as a substitute for compressed air or other gases.

(3) Use a friction lighter or pilot lighter to light torches - Never Use Matches to Light a Welding Torch!

(4) Protect the eyes by wearing goggles or head shield woth suitable lenses when using a torch.

(5) Wear leather gloves, protective shoes, and clothing that is completely free of oil with pockets and cuffs protected from sparks or hot metal. Do not hang articles of clothing on cylinders, because clothing may become saturated with acetylene and explode or ignite.

(6) Ventilate working areas. Do not use oxygen for ventilation. Make sure that oxygen concentrates above normal cannot be developed in the work area. Leave gas cylinders outside when working in small enclosures.

(7) Always call acetylene "Acetylene" - "Not Gas". Call oxygen "Oxygen" - "Not Air". The word gas is a general term and confusion here is dangerous. The use of the term "Air" instead of the word "Oxygen" may lead to a serious accident.

b. Safety rules to observe when handling cylinders include:

(1) Keep oil and grease away from cylinders and never use these types of lubricants on the valves or connections.

(2) Use cylinders in rotation as they come from the supplier. Mark the empty cylinders and send marked cylinders back to the supplier promptly. Also, keep "empties" and "fulls" separate to avoid serious results. Keep the valves closed on "empties".

(3) Keep cylinders away from exposures to sparks, hot slag, open flame, and all possible sources of excessive heat.

(4) Always secure cylinders in an upright position to a suitable support. Letting a cylinder fall can be dangerous. Also, transport and store cylinders in an upright position. Do not attempt to lift cylinders with make-shift equipment. The most popular cylinder mount is the cylinder cart.

(5) Refer to:

Oregon Safety Code
"Gas and Electric Welding"
Workmen's Compensation Board
Labor and Industries Bldg.
Salem, OR 97310

This bulletin will give all legal requirements for storing and handling O-A cylinders.

(6) Never use cylinders as a ground or a source of an electric circuit. Do not strike an arc on a cylinder with the electric arc unit and do not hit the cylinder with any object, especially if the object is metal.

(7) If cylinder valves cannot be opened by hand, never use a hammer or wrench; notify the supplier and if leaks appear, move cylinder out of shop area and also notify supplier.

Safety practices to observe when attaching and using the welding unit apparatus are as follows:

(1) Keep all apparatus clean and free from oil. Do not use oil on the regulators - oil and oxygen can cause dangerous explosion.

(2) Open each cylinder valve slightly, for a very short time, before attaching the regulators to clean the cylinder valve of dust and debris before attaching the regulators.

(3) Open the cylinder valves slowly after attaching the regulators, allowing the hand on the cylinder guage to move slowly on the dial away from the pin. A full oxygen tank contains about 2000 psi (pounds per square inch) and a full acetylene tank 250 psi.

(4) Do not use defective or leaky apparatus - have it repaired. Matches or any type of flame should not be used to test for leaks. The use of soapy water is safe when testing for leaks. Use a paint brush to apply the soapy water on connections.

(5) Stand to one side of the regulators when making valve and regulator adjustments.

(6) Use wrenches on blowpipes and other connections only as directed by the manufacturer. Most blowpipes are designed for hand tightening.

(7) Use as short a hose length as possible. Remember,

longer the hose, the higher the pressure required. Hose leaks must not be repaired with tape. A leaky hose should be replaced with a new hose. Do not kink the hose, as this practice injures hose linings. Keep sparks and hot metal away from hoses.

(8) Do not attempt to repair torches or regulators unless properly trained.

(9) Never put acetylene under a pressure of more than 15 psi. Acetylene over this pressure tends to be unstable and its reaction less predictable.

(10) After finishing a welding job, first turn off the acetylene torch valve and then the oxygen valve. The hose color will identify the two different gases.

(11) Prevent fires by keeping tips clean, using proper pressure, keeping connections tight, properly heating metal, keeping tips firmly seated, and using friction.

(12) Keep fire extinguisher ready to use in case of fire.

d. Some general safety practices to observe include:

(1) Never weld or cut on containers that might have been used to hold flammable materials. Some of the most serious accidents are caused by working on this type of item. The weldor may still be in danger even if the container is filled with water.

(2) Cut and weld only when under the supervision of an experienced teacher or weldor. Safety practices are respected by these people.

4. Equipment Necessary for Oxyacetylene Cutting and Welding - Setting Up Equipment

Transparency No. 2

a. Equipment

(1) Cylinders - The two types of cylinders are oxygen and acetylene. Both types are made to hold gases in cubic feet measures. The sizes of oxygen cylinders are 244, 122, and 80 cubic feet. Acetylene cylinders are measured in 300, 100, and 60 cubic feet. These cylinders are equipped with a safety device to let the gases drain slowly if heat causes the pressure to rise.

(2) Regulators - Both oxygen and acetylene regulators have two guages; one gives the amount of pressure in the cylinder and the other the torch pressure. Most modern welding equipment funtions best with equal pressures on both the oxygen and acetylene regulator line adjustments. Follow the manufacturer's recommendations on tip size and pressure. The following chart will help for most applications.

O_2 Pressure	C_2H_2 Pressure	Metal Thickness	Size of Tip
2	2	1/16	1
4	4	1/8	3
6	6	1/4	5

* Note: Economically, a person cannot justify O-A welding metal thicker than 12 guage. Metal at 1/8 inch or thicker should be Arc welded. Practice O-A welding in vocational agriculture should be done on 16-14 guage metal - no thicker.

(3) Cutting Torch - The cutting torch provides a pre-heat mixture of oxygen and acetylene for heating the metal and a pure stream of oxygen for blowing the heated metal from the intended cut. The torch is equipped with both oxygen and acetylene valves and a cutting valve lever that controls pure oxygen.

(4) Welding Torch - This torch is also equipped with a gas mixing chamber. The gases are controlled by the two valves located at the back of the torch handle.

(5) Hoses - A special type of non-porous hoses carry the oxygen and acetylene from the regulators to the torch. Oxygen hoses are usually green or black, and acetylene hoses are red in color. Oxygen hoses have right-hand threads and acetylene left-hand.

(6) Cutting and Welding Tips - Cutting tips have four, six or eight preheat orifices and once cutting orifice. This orifice is located in the center of the tip. The thickness of metal regulates the size of the tips to be used. Welding equipment manufacturers identify tips by both letter and number. Heat and flame from the preheat holes form the inner cone. This cone has a short flame, whereas the cutting oxygen flame is long.

(7) Welding Tips - Different sizes of welding tips, like cutting tips, are interchangeable on the blow-pipe. The size is also similar to that of the cutting tip in that it is governed by the orifice. Welding tips only have one orifice. However, the numbering system which regulates sizes (ranging from 00 - 15) depends on the tip manufacturer.

(8) Necessary Miscellaneous Equipment - The friction lighter is the only safe type of lighting equipment used. It lights both the cutting and welding torch. Open end or adjustable wrenches are used on the regulator and torch connections. Wrenches are usually supplied with a welding unit. In the tip cleaning set, cleaners are made to fit the orifices in both cutting and welding tips. Such items as soapstone for marking, c-clamps for holding stock, and wire brushes for cleaning metal are essential in a welding and cutting outfit.

(9) Weldor's Clothing - The operator should not attempt to cut or weld metal without protective goggles. They protect the eyes against dangerous rays, glare, and sparks. Fire-resistant gloves are recommended for welding to protect the hands against heat radiated by the torch and metal. Clothing should be of the type that protects the body against sparks and heat.

b. Setting up equipment involves the following steps:

(1) Fasten Cylinders - After fastening cylinders either in a portable cart or against the wall, remove the protective caps, and crack valves slightly to clean foreign matter from inside the nozzles, then close the valves.

(2) Connect Regulators - Fasten regulators to respective cylinders and tighten union nuts. Open the regulator adjusting screws by turning counterclockwise until they feel loose, then open the cylinder valves very slowly, allowing the pressure to move the guage hands (oxygen and acetylene) on the dial very slowly. On some acetylene cylinders a T-wrench is used to open the acetylene valve.

(3) Connect Hoses - Attach the red hose to the acetylene regulator and the green or black hose to the oxygen regulator. Note: right-hand threads are on the oxygen hose and left-hand threads on the acetylene hose. It may be necessary to turn the regulator adjusting valves clockwise to blow the hose out. About 5 pounds of oxygen will clean the hoses. If the acetylene hose is cleaned with oxygen, it is attached to the oxygen regulator with a special connection. Assuming the blowpipe needs cleaning, open both blowpipe or torch valves after the torch is connected to the hoses and blow the torch out with about 5 pounds of oxygen pressure.

(4) Select and Insert Cutting or Welding Tip - After the proper size of cutting tip is selected, it should be attached securely. The welding tip is tightened by hand. Tips are selected according to the thickness of metal. For example, a welding tip 00 is used on thin metal (1/32 inch or less), whereas a number 14 tip is used to weld thick metal (1 inch

and over). The right size tip will let gas flow at the proper rate for fusing metals together.

(5) Turn on Unit - Fully open the oxygen cylinder valve and turn the acetylene 3/4 to one turn open. With the oxygen needle valve open on the torch, adjust the pressure guage to the desired working pressure and then close the needle valve. The same procedure is followed for regulating the acetylene.

(6) Test for Leaks - Use soapy water and a paint brush to check for leaks at the following points:

Transparency No. 2

(a) Oxygen and acetylene cylinder valves
(b) Regulator valve inlets
(c) Hose connections at regulators and blowpipe or torch
(d) Area around needle valves
(e) Area around tip connections

5. Oxyacetylene Cutting Parts and Adjustments

Transparency No. 3

a. A different type of torch (blowpipe and tip) is used for cutting metal than is used for welding. The cutting tip has 4 to 8 holes located around the center hole. These small orifices (holes) furnish flames to preheat the metal, and the center orifice furnishes oxygen to cut the metal.

b. An oxyacetylene cutting torch has three controls. They are: Preheat oxygen valve, preheat acetylene valve, and a cutting oxygen valve that is controlled by a lever. The two preheat valves actually furnish heat on the surface to a kindling temperature of the steel being cut and the cutting oxygen controlled by the lever ignites the molten metal and blows it from the heated area.

c. Lighting and adjusting the blowpipe are very important steps when cutting metal. If the manufacturer's instructions are not available, the following procedure may be used:

(1) Hold the blowpipe with the tip pointing away from the body. Open the acetylene valve about 1/4 turn and light the torch with the friction lighter. The flame should clear the tip end about 1/8 inch when first lit, but it should be adjusted back to the tip.

(2) Adjust the regulator pressure by turning the adjusting screws clockwise. Oxygen pressure depends on the thickness of metal being cut usually 15 or more pounds per square inch. For example, 1-inch thick metal requires about 30 psi. Acetylene pressure varies from 3 to 5 psi and <u>never</u> exceeds 15 psi.

(3) Adjust the preheat oxygen valve until a neutral flame appears with sharp inner cones, then press the cutting oxygen lever and readjust the flame by turning the preheat oxygen valve while the cutting lever is in the downward position. Then readjustment is to correct the flame from carburizing to neutral when rising the lever.

6. Cutting Metals

Transparency Nos. 3, 4, and 5

a. The metal to be cut should be clean, marked with a punch or soapstone, and placed in a suitable position for cutting. The position can also involve the location for cutting. For example, moisture in a concrete floor will cause small pits where the hot metal falls. This can be prevented by using a container to catch the molten metal. Hot metal will also damage welding unit hoses and may even cause fires.

b. Cutting metals by using the oxyacetylene process is more or less limited to ferrous metals such as carbon steels, alloy steels, low chromium steels, and manganese steels. Steels with a high tungsten or chromium content or stainless steel cannot be cut with oxyacetylene heat. Cast iron is more difficult to cut than steel; therefore, an excessive acetylene flame is used to cut thick cast iron. Also more oxygen is needed due to more heat being required than when cutting malleable steel. The cutting tip is held at 45 degrees to start the cut and is raised to about 75 degrees to make the cut.

c. The steps to follow in making a cut are:

(1) Hold the blowpipe perpendicular to the surface of the metal unless bevels are to be cut. Place flame inner cone within 1/16 to 1/8 inch above the plate or metal surface edge. Metal will not stack on the tip if it is held at a proper distance from the surface. Hold the tip so that two preheating holes are in line with the oxygen hole.

(2) Hold the torch at the edge of the metal until the metal begins to melt. The top of the torch may be slanted toward the cut and changed to a vertical position as the cut progresses.

(3) Press down slowly on the oxygen cutting lever until the cutting valve is completely open. When the cut is through the metal, move the torch along the line.

(4) Tilt the torch tip slightly toward the direction of cut on thin metal. It should be held vertical on thick metal when making a straight cut.

(5) Move the torch slowly along the surface or the oxygen stream will not pass completely through the metal. The cut can be restarted by releasing the cutting lever and reheating the metal again before

pressing the cutting lever. Irregular edges may be caused by losing the cut.

(6) When beveling plate edges or cutting at an angle, lean the tip at the desired angle and hold the torch parallel to the work.

d. Steps that may be followed when piercing holes include:

Transparency Nos. 4 and 5

(1) Hold the blowpipe in the same position (tip perpendicular to the surface) until a spot on the surface begins to melt.

(2) Raise the blowpipe (torch) until the end of the nozzle is about 3/8 to 1/2 inch above the surface and slowly press the cutting lever as the torch is raised.

(3) Move the tip to one side of the heated area so that the slag (non-metallic material in the heated metal) can be blown out.

(4) Move the inner cone within about 1/8 inch from the surface and make the cut on the inside edge of the hole.

(5) To facilitate the cutting of a hole in thick metal, drill a hole 1/4 inch or larger by using a twist drill and start the piercing in this hole.

7. Lighting and Adjusting the Welding Blowpipe

Transparency No. 6

a. Steps to observe when lighting the blowpipe include:

(1) Hold the torch in one hand and the friction lighter in the other. The welding goggles should be pulled over the eyes.

(2) Open the torch acetylene valve about 1/8 to 1/4 turn with the tip pointing away from the body and cylinder. The lighter should be held about an inch from the point of the tip while lighting the torch.

(3) Open the acetylene valve until the flame stops excessive smoking and breaks away from the tip about 1/8 inch. The flame is then reduced slightly to bring it back to the tip. If there is a backfire, the flame will go out with a pop. Check the pressure, connections, and heated tip to correct problems.

(4) Open the oxygen valve slowly until a smoothly rounded inner cone appears, creating a neutral flame. The neutral flame is recognized as the oxyacetylene welding flame. Even though the neutral flame is used for hard surfacing. Flame descriptions are as follows:

(a) Neutral Flame - This flame does not show any

acetylene feather. It does not have a feathery edge, but the flame has a smoothly rounded inner cone.

(b) Carburizing Flame - This flame is caused by using an excess of acetylene. It has an inner cone and acetylene feather. It is the largest of the three types of flames, and is usually the first flame to appear when lighting the torch.

(c) Oxidizing Flame - An oxidizing flame has an excess of oxygen. The smaller inner cone has a sharp point. The main body of the flame is smaller than the other two types of flames. The flame may be used for braze welding with a bronze rod.

8. Turning Off the Blowpipe (Torch)

a. First the acetylene valve is closed on the torch and then the oxygen valve is closed. This assures the operator that the flame is out, thus reducing the possibility of a flash-back which is caused by a carbon deposit in the tip.

b. The oxygen torch valve is the second valve closed. This procedure is followed by closing the acetylene and oxygen cylinder valves.

c. The acetylene and oxygen torch valves are opened to release hose pressure and then they are closed again.

d. The acetylene and oxygen regulator adjusting screws are backed out until they are loose.

9. Caring for Welding Tips

a. Welding tips frequently become separated with metal or other materials that may cause inferior work. Tips are cleaned in the following manner:

(1) The tip point can be rubbed with emery cloth or steel wool; foreign material and metal is removed by this method. The emery cloth may be place on a flat surface with the grit side up and the tip point passed squarely over it.

(2) Tip cleaners should be used to clean the orifice of the tips. The edge of the orifice should remain square. The cleaner should have the same number as the tip.

(3) If the oxygen valve is opened slightly at the time the tip cleaner is carefully pushed in and pulled out of the opening, the foreign particles will be blown out of the tip.

b. Proper handling of the tip

(1) The threads and seats can be damaged easily; therefore they should be stored in a rack for protection.

(2) Most tips can be replaced in a welding blowpipe by

hand; but if a wrench is needed to set the tip, it should not be overtightened.

(3) Care should be observed when inserting the tip into the blowpipe. Tip threads are very easily damaged; crossthreading will ruin the tip.

10. Preparing Metal for Welding and Proper Positions of Blowpipe and Tip

a. Preparing metal for welding is as follows:

(1) Before a good weld can be made the metal must be free of oil, paint, grease, dirt, rust, and other foreign matter. Metal can usually be cleaned by heating it with the torch and then brushing it with a wire brush.

(2) Thick metal can be beveled on one or both sides either by using a grinder or by the use of the oxyacetylene cutting torch. Beveled edges will allow the metal to fuse together and make a stronger joint.

(3) Some types of work require that the metal be aligned before welding; therfore, tack welding is necessary to hold the metal in line during the welding operation. The tack welds may become part of the finish weld.

b. Proper blowpipe and tip positions are:

Transparency No. 6

(1) The blowpipe may be held similar to a hammer when welding in a standing position. It can be held like a pencil when welding in a sitting position.

(2) The blowpipe should be held so that the tip will be at a 45-degree angle to the surface. The welding rod should also be held at about a 45-degree angle to the surface and in line with the weld.

(3) The tip should be held about 1/4 inch above the surface. The inner cone flame should be 1/8 inch to 1/16 inch above the metal.

(4) Preheating the metal is very important in making a successful weld; therefore, the flame should be moved in the direction of the weld, and the cone should stay inside the puddle (molten pool of metal).

11. Oxyacetylene Welding Procedures

Transparency No. 7

One of the most important steps in learning to weld with oxyacetylene is to carry a molten puddle of metal along the line or seam of the parts to be joined together by the weld.

a. Forming the puddle and running the bead include the following practices:

(1) The flame is held at the starting point until a bright round pool (1/4 inches diameter) is formed. This puddle width is actually determined by the depth of penetration and motion of the torch. If a 3/16-inch wide puddle or pool is formed, the speed of welding should maintain that width. If the speed is correct, the puddle will be formed under the inner cone of the flame. Usually, the inner cone is held from 1/16 to 1/8 inch above the surface. If the speed is too slow, the torch flame will burn a hole through the metal or form a large pool. If the speed is too fast, the blade will be irregular and narrow.

(2) No motion with the torch is necessary; however, several types of torch movement patterns are commonly used. The circular motion is frequently used when fusion welding is being done. The weaving or zig-zag pattern is also used when fusion welding, but with the use of a filler rod. When using either pattern, the torch should be held at about 45 degrees to the surface or weld. The welding fiber rod should be held at 45 degrees but slanted away from the torch tip. It is recommended to use a rod equal to the thickness of the metal. The torch should be held so the tip is pointed in the direction of the weld (forehand).

(3) After a bead is finished, it should be examined for the following characteristics:

(a) Uniform width
(b) Free of excessive scaling
(c) Clean and bright
(d) Slightly higher than the base metal surface and penetrating the base metal

b. When using a welding rod to make a fusion weld the following procedure may be used:

(1) Select two pieces of 16-guage sheet steel about 3 inches long and 1 inch wide and a 1/16-inch filler rod.

(2) Tack weld at each end, leaving a very small space (about 1/32 inch) between the two pieces.

(3) With the torch in one hand and the welding rod in the other, heat the two pieces at the starting point (one end) and then heat the welding rod before dipping it into the molten puddle. Make an up and down motion of the rod, dipping the end of the rod in the molten pool of metal. When using the circular motion remove the rod from the puddle as the flame is moved to the front of the puddle. Before starting the weld, bend the rod 8 inches from the welding end to about a 120-degree angle. It is easier handled in this shape.

(4) As the second tack weld is reached, remelt it into the pool or puddle.

12. Common Types of Welds, Welding Joints, and Welding Positions

Transperency No. 8

a. The two most common types of welds are butt and fillet. When two pieces of metal are butted together and welded, with or without beveling, the term used for this practice is butt welding. If metal pieces are joined together forming a right angle or tee, this is known as T-welding or fillet welding.

b. The four most common types of welding joints are:

(1) Butt-Joints are butted together or almost together and usually parallel to each other.

(2) Tee - One piece of metal is placed on a second piece forming a T and two 90-degree angles.

(3) Corner - Two edges touching each other forming a 90-degree angle.

(4) Lap - One part of a piece of metal lapping over the other.

c. The most common types of welding positions include:

Transparency No. 9

(1) Flat- This position is the easiest and most common position used. It is the position where welding is learned. Torch and rod manipulation are both practiced in this position before attempting to use the other three positions.

(2) Horizontal - This welding position is considered difficult due to the pool of metal having a tendency to run from the top to bottom edge. The pool should be kept small and not as hot as in the flat position. If possible, the flame and filler rod should be directed upward from the bottom edge to reduce rapid melting of pool metal.

(3) Vertical - This weld can be made with the rod following the flame or the flame following the rod. If the flame follows the rod, it must be slanted. In this way heat is directed ahead to reduce the possibility of the pool running over.

(4) Overhead - This is the most difficult position due to its being awkward for the operator. A metal drip from the heated pool should not be allowed to form. The flame should be slanted and ahead of the pool.

13. Welding Different Kinds of Metals

a. Cast iron is welded with both bronze and cast iron rods. Cast iron rods require higher preheating than bronze rods. Bronze is used extensively to repair cast iron unless the

color of the base metal must be matched. Many iron castings are made of malleable iron that requires bronze-welding.

(1) Practice procedure for welding cast iron

Transparency No. 10

(a) Select a flux for welding cast-iron with a cast iron rod.

(b) Clean and bevel the edges of the work stocks (two pieces of 1/8 inch cast-iron).

(c) Use a 3/16-inch rod with a neutral flame, and tack ends together before starting weld.

(d) Heat the rod to a red-colored heat and dip it in the flux, then dip the tip in the molten puddle of cast-iron. Pool heat should melt the rod.

(e) Continue to weld in the same manner as making a fusion weld in mild steel. Dip the hot tip of the rod in flux from time to time. Add more flux if bubbles appear and pass the flame over the weld.

A flux is a chemical compound that is used to promote the fusing of metal and prevent an oxide coating from forming on the metal being welded. Some of the newest type welding rods have a flux coating. The major types of flux are bronze, cast-iron, and aluminum.

(2) Practice procedure for braze welding

Transparency Nos. 11 and 12

Braze welding fuses the bronze from the rod with the metal being welded. The main advantage of braze welding is that it does not require a very high welding temperature that may change the malleable properties of the metal. The procedure is as follows:

(a) Clean the surface to be welded of all dirt, paint, scaled metal, and other foreign matter by filing, sanding, buffing, chipping, or grinding.

(b) Align the edges of metal strips (1/8 inch thick) so that they almost touch. The edges should be beveled if they are more than 1/8 inch thick.

(c) With a neutral flame heat the end of the rod and dip it into the flux.

(d) Heat the area on each side of the base metal joint to a dull red and tack ends.

(e) Apply flux from rod on heated area, then pass rod into flame and deposit a small amount of bronze at intervals until the weld is complete. Flux should be added from time to time.

b. Hard surfacing practice procedure

(1) Hard surfacing is the application of an all alloy material to another metal for the purpose of reducing wear. Metals that are subjected to abrasive wear such as cultivator sweeps, plow shares, and horseshoes can be hardsurfaced.

(2) The procedure for hardsurfacing is as follows:

(a) Thorougly clean the metal before applying alloy.

(b) Place the material to be hard surfaced in a flat position.

(c) Heat a small section of the area with a welding flame that contains an excessive amount of acetylene until the metal begins to sweat.

q

(d) Touch the tips of the alloy rod to the surface and melt enough of the rod to form an alloy cover 1/16 inch thick and a desirable width without heating the base metal to a melting point.

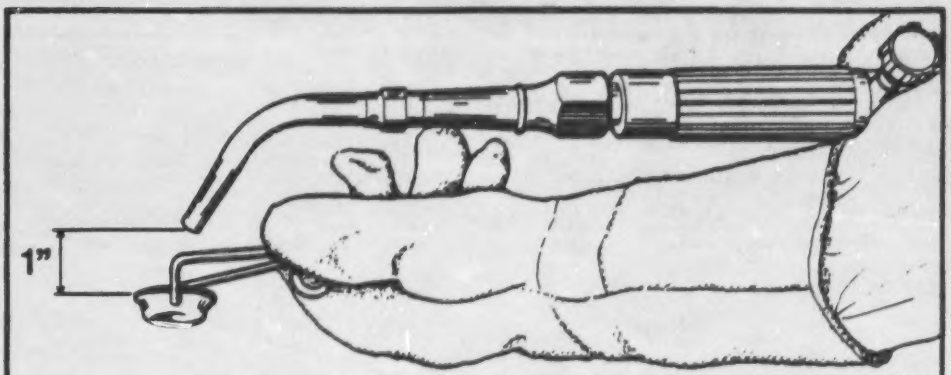
(e) Maintain a hard surfacing temperature in front of the path of the hard metal. Add just enough of the rod to the metal to maintain a uniform thickness and width. The width will vary according to the material being welded.

(f) Hard surfaced metal should be allowed to cool slowly. Ashes or dry lime serves as a good cover for cooling metal.

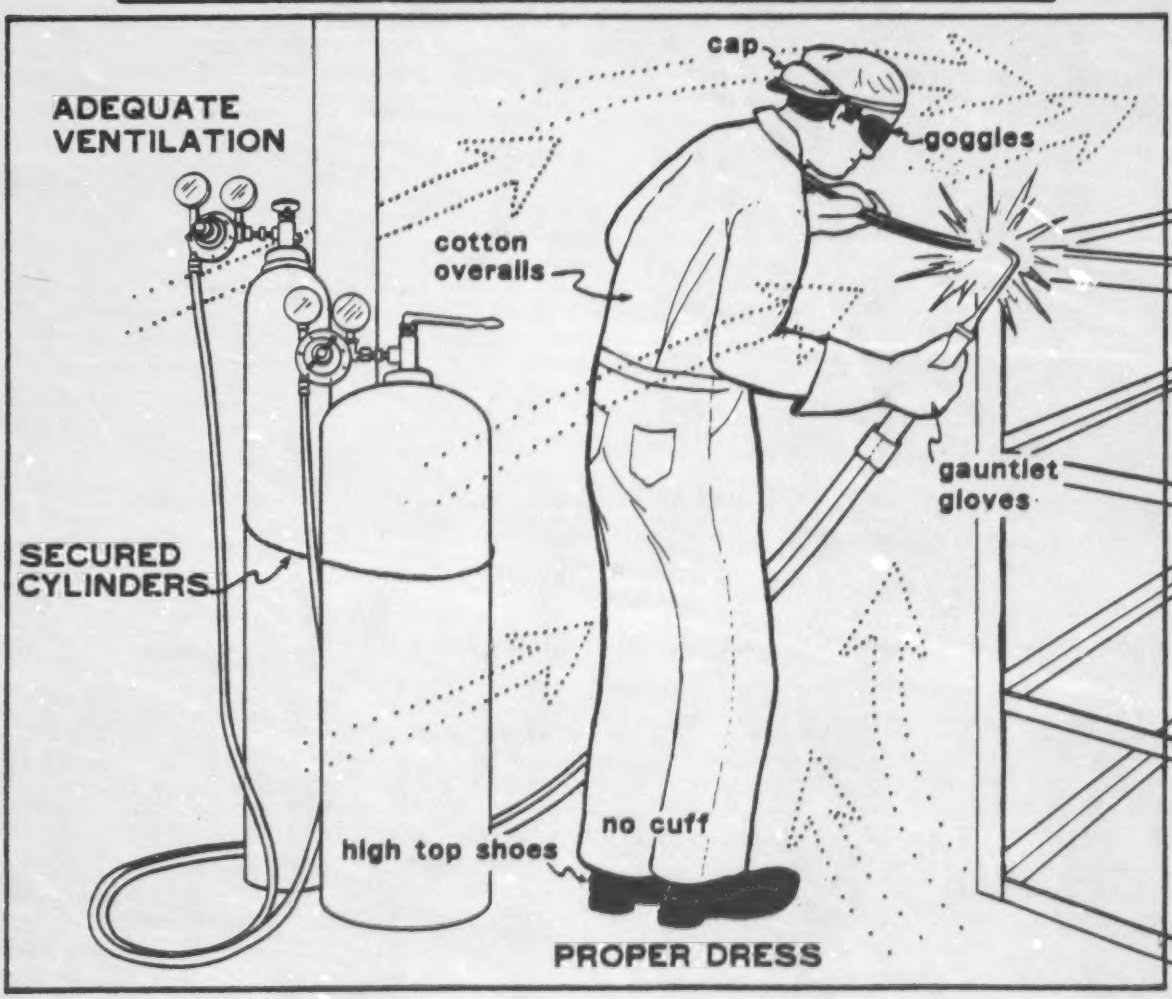
14. Suggested Assignments

1. Flat butt weld with steel filler rod on 16 guage steel.
2. T-Fillet with steel filler rod on 16 guage steel.
3. Braze cast-iron using 1/8" or 3/16" pre-fluxed brazing rod.
4. Butt weld around a "stationary" (in a vice) piece of exhaust pipe (this activity includes flat, vertical-up, vertical-down, and overhead welding).
5. Hardsurface a plow share or cultivator tip.
6. Cut a straight line, bevel and pierce a hole with the cutting torch.

SAFETY PRACTICES

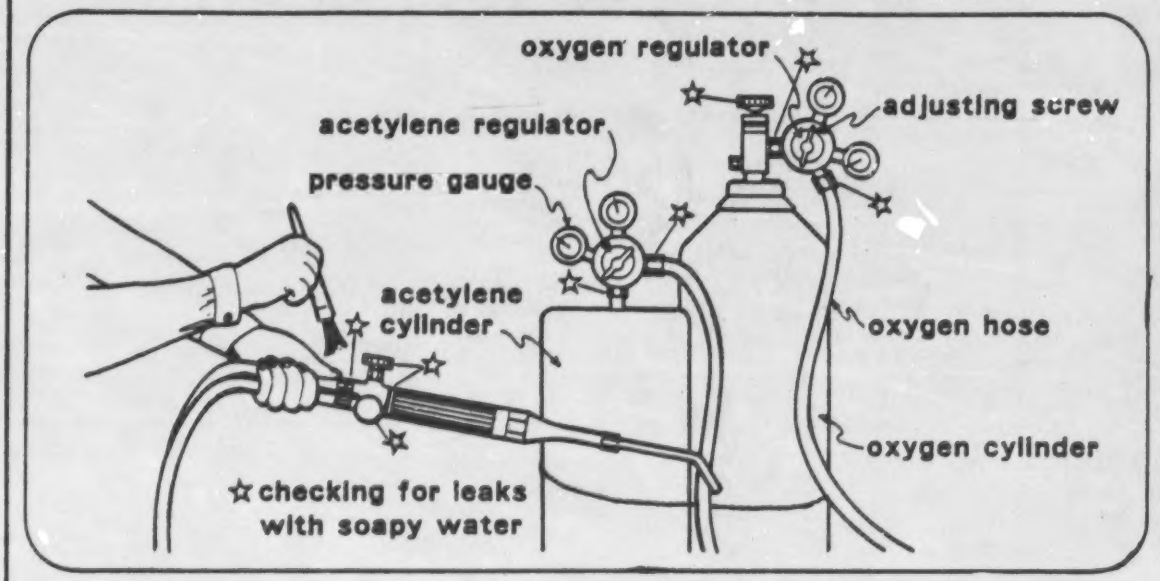


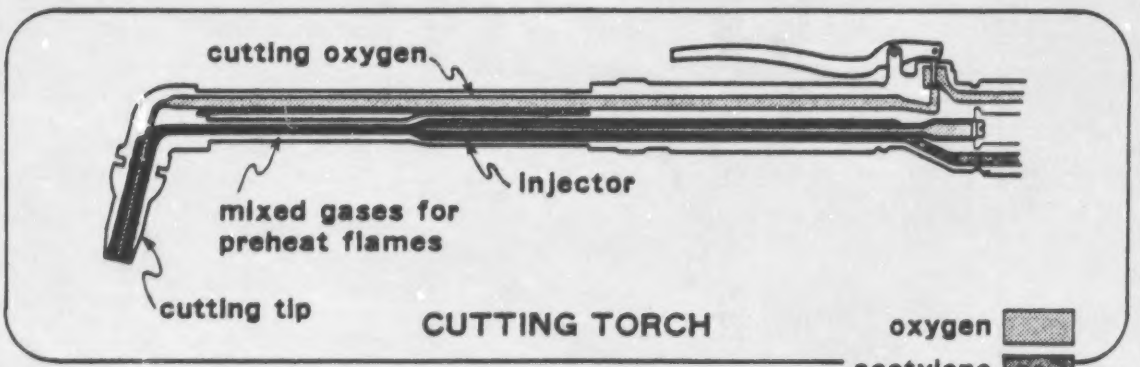
USING FRICTION LIGHTER

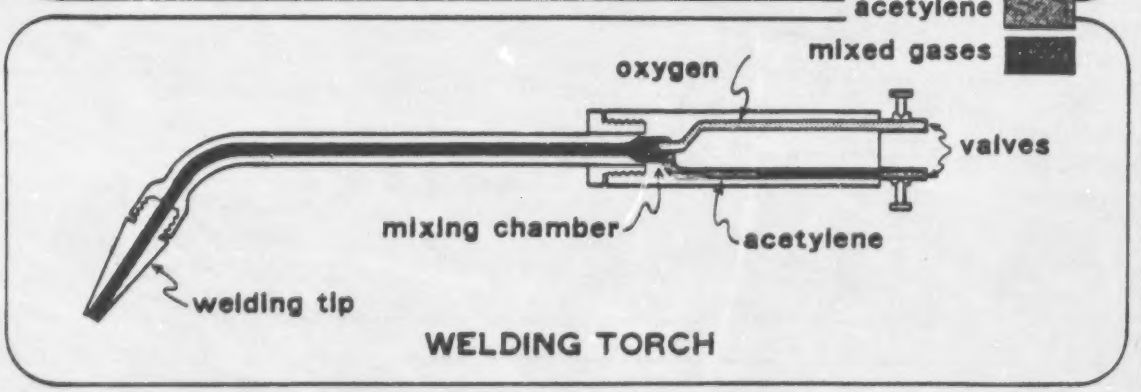


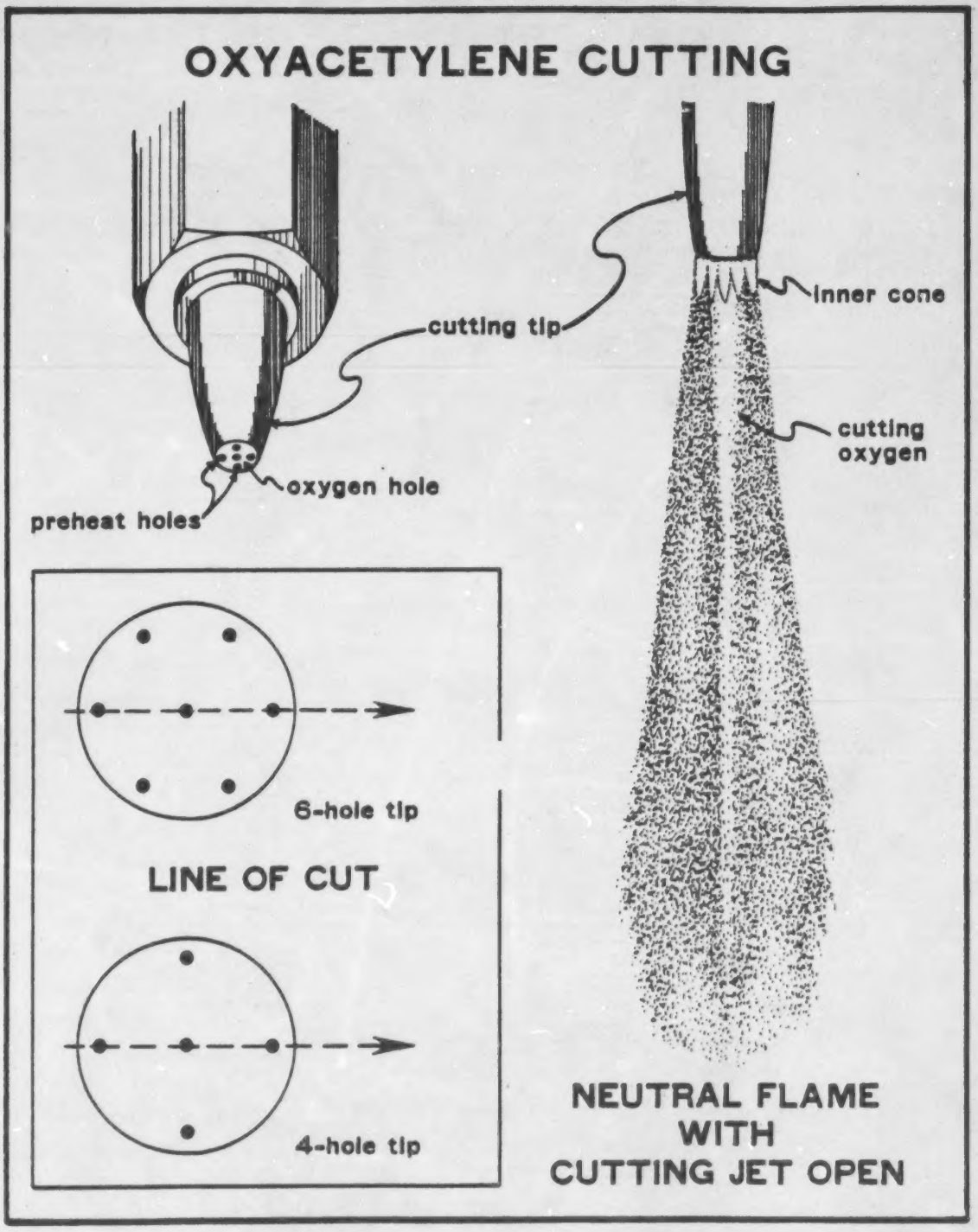
PROPER DRESS

OXYACETYLENE EQUIPMENT

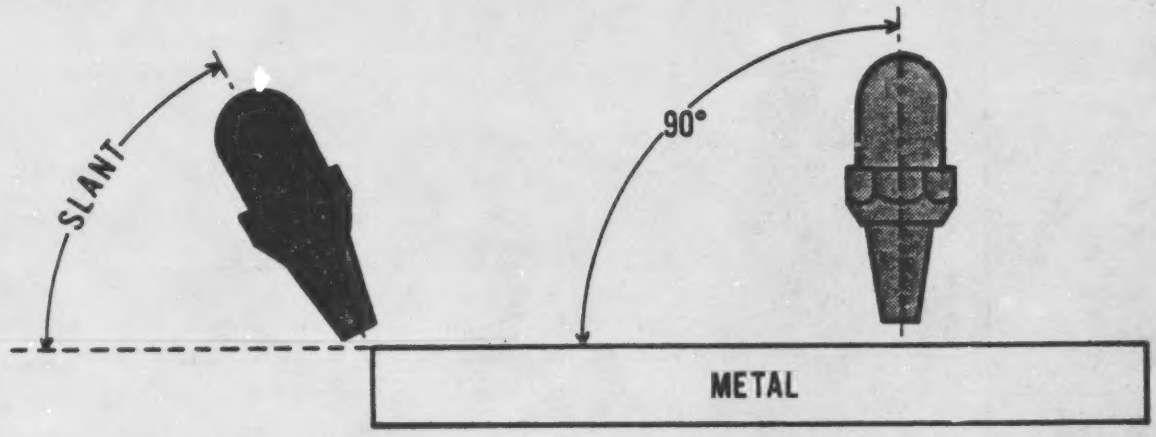






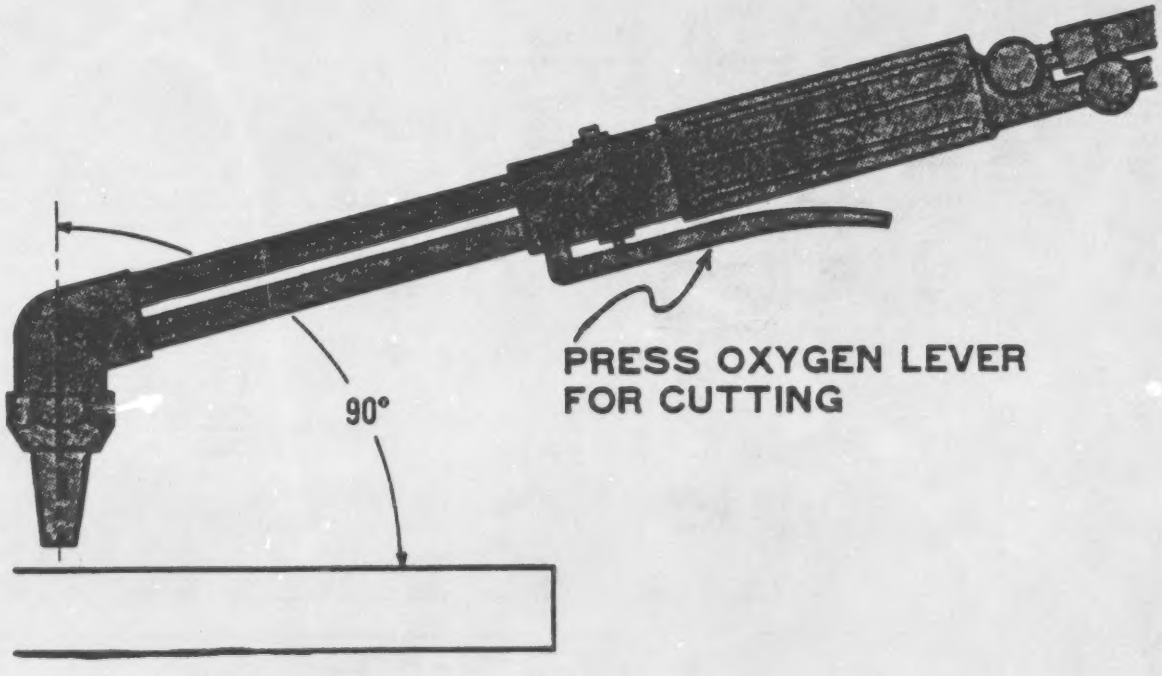

OXYACETYLENE CUTTING
cutting tip
inner cone
cutting oxygen
oxygen hole
preheat holes
6-hole tip
LINE OF CUT
4-hole tip
NEUTRAL FLAME WITH CUTTING JET OPEN

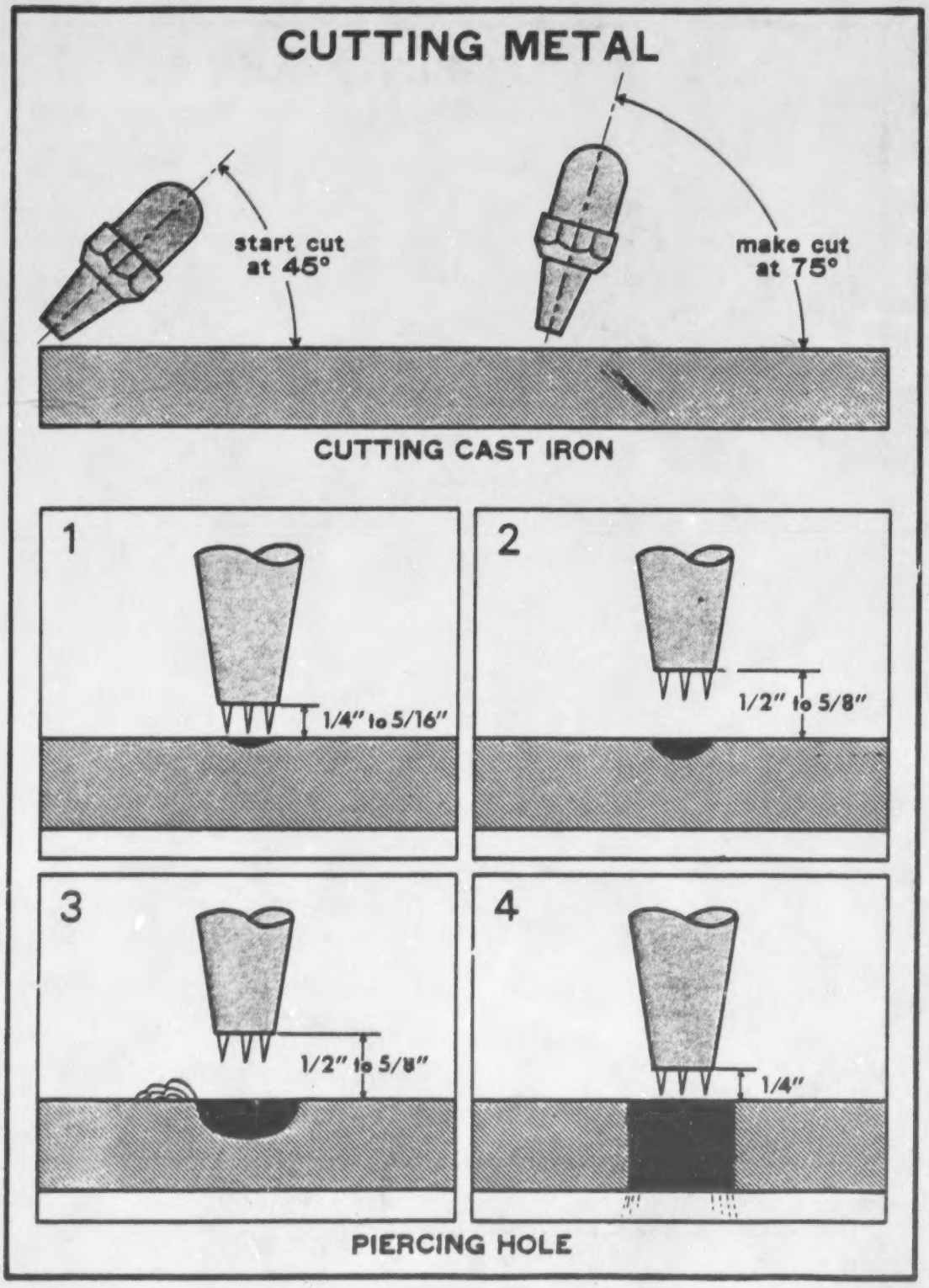
CUTTING METAL



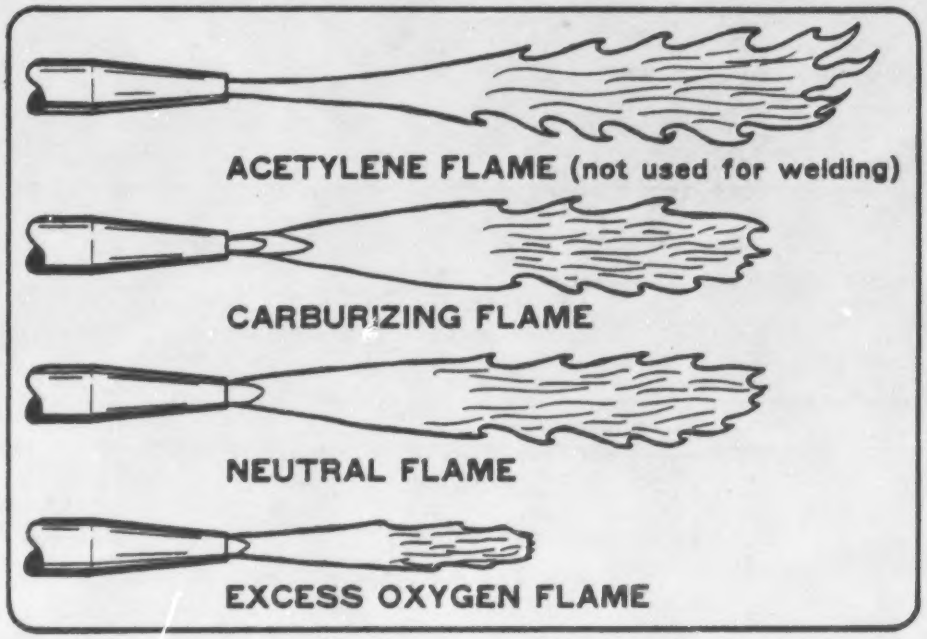
TORCH TIP SLANTED TO START CUT

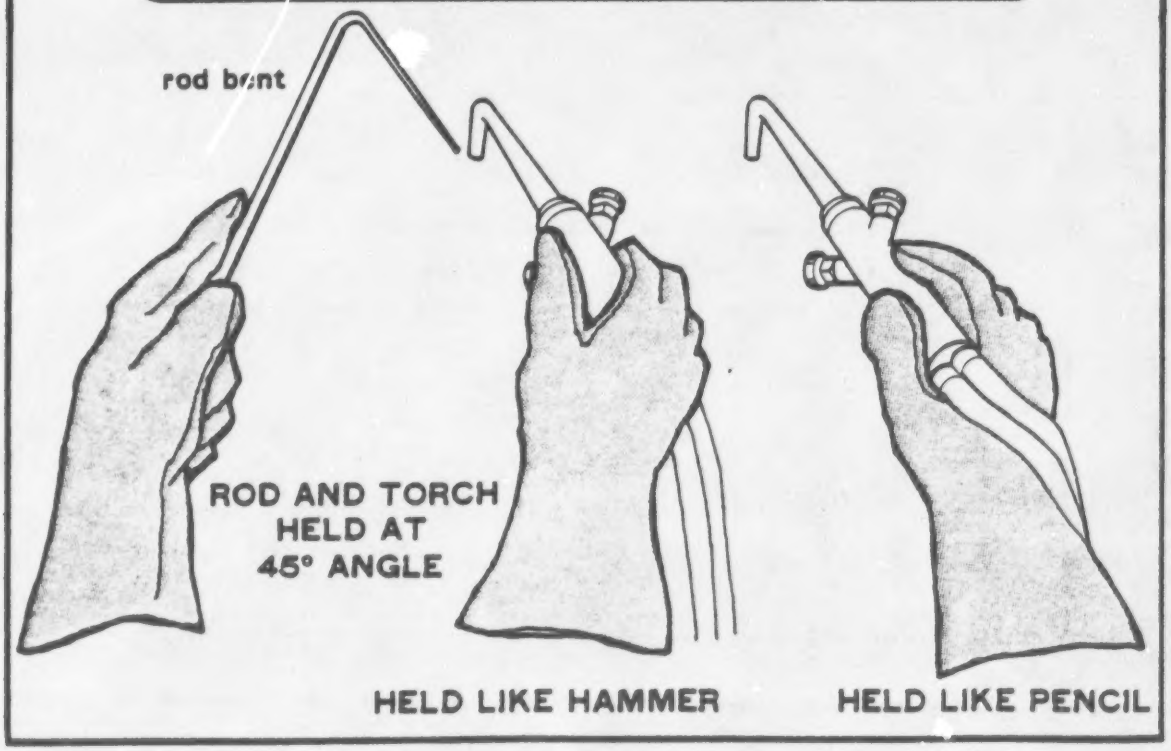
GRADUALLY MOVE TORCH TIP TO PERPENDICULAR POSITION



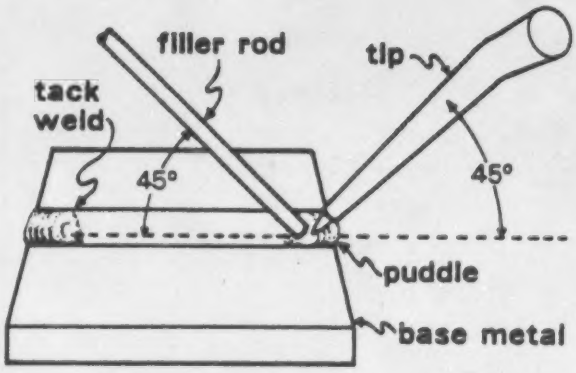

CUTTING METAL
start cut at 45°
make cut at 75°
CUTTING CAST IRON
1
1/4" to 5/16"
2
1/2" to 5/8"
3
1/2" to 5/8"
4
1/4"
PIERCING HOLE

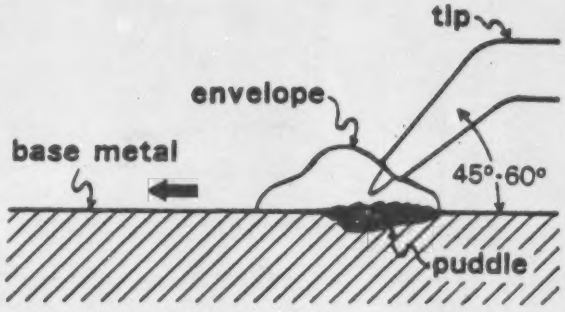
KINDS OF WELDING FLAMES AND TORCH POSITIONS

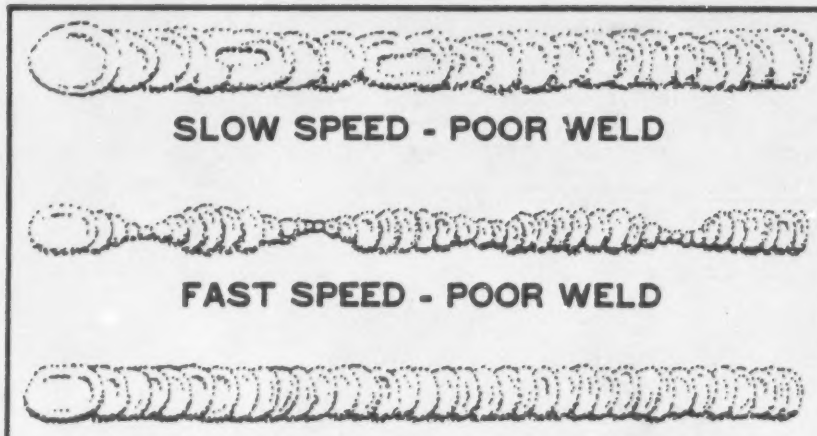


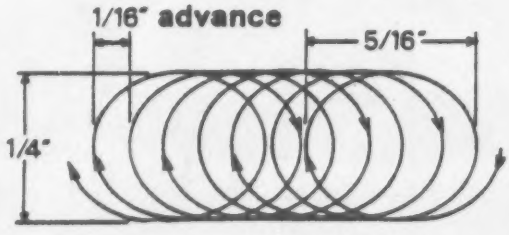


WELDING PROCEDURES

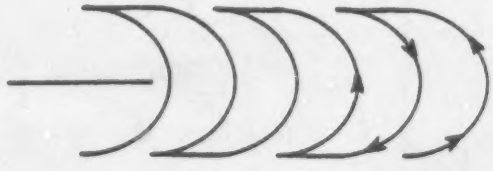






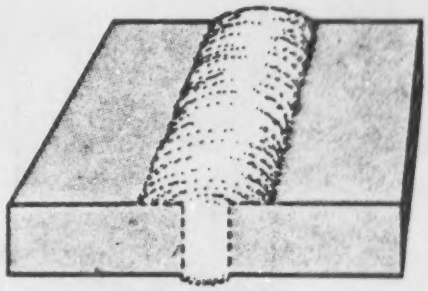


CIRCULAR MOTION

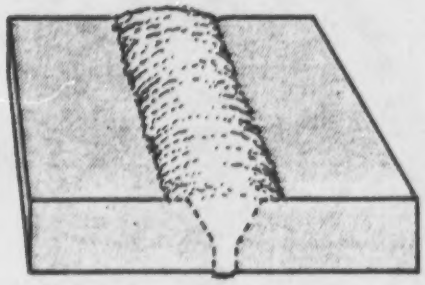


ZIGZAG MOTION

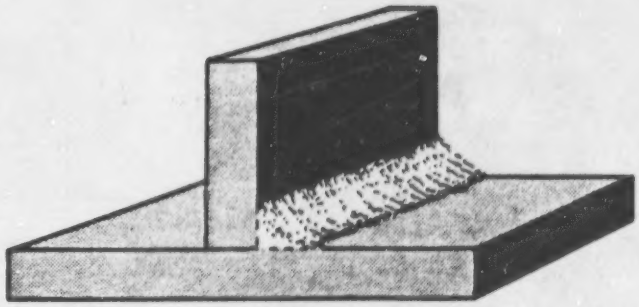
COMMON TYPES OF WELDS AND JOINTS



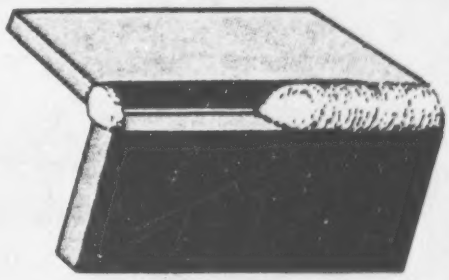
BUTT WELD



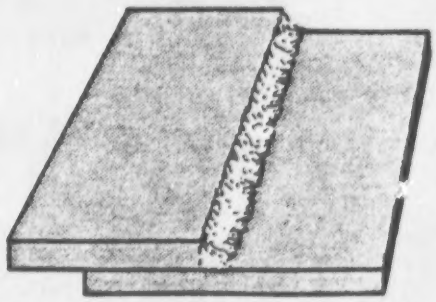
BEVELED BUTT WELD



TEE WELD

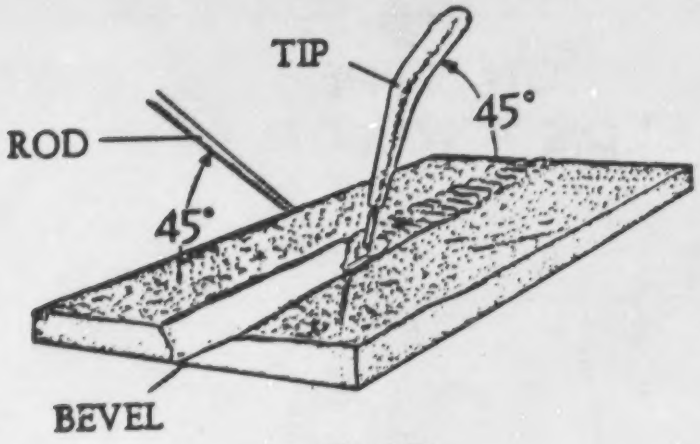


CORNER WELD

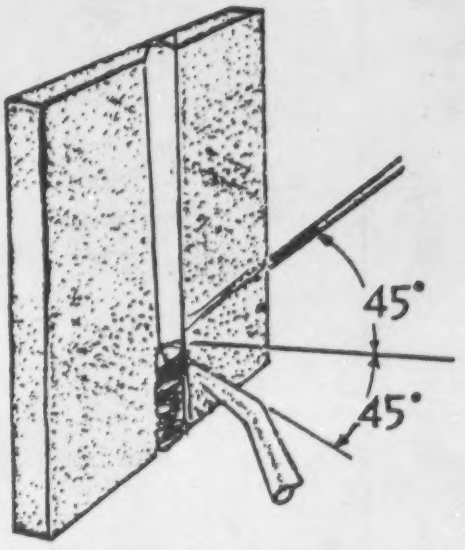


LAP WELD

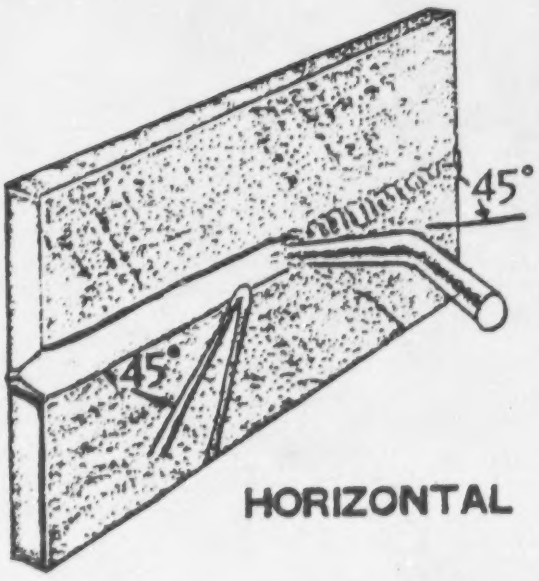
OXYACETYLENE WELDING POSITIONS



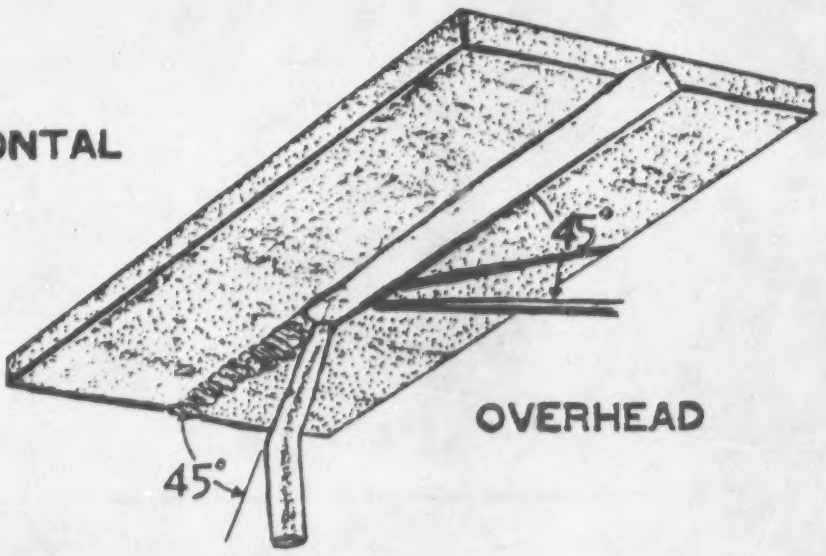
FLAT



VERTICAL

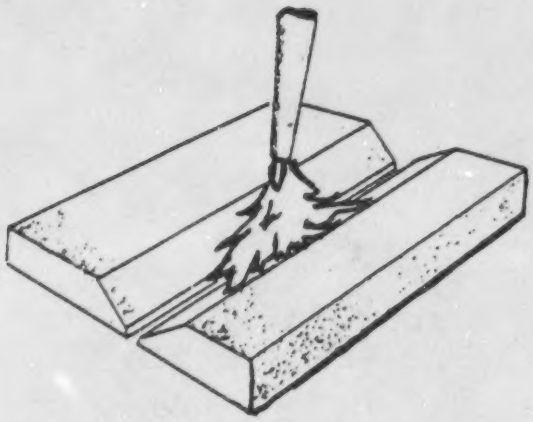


HORIZONTAL

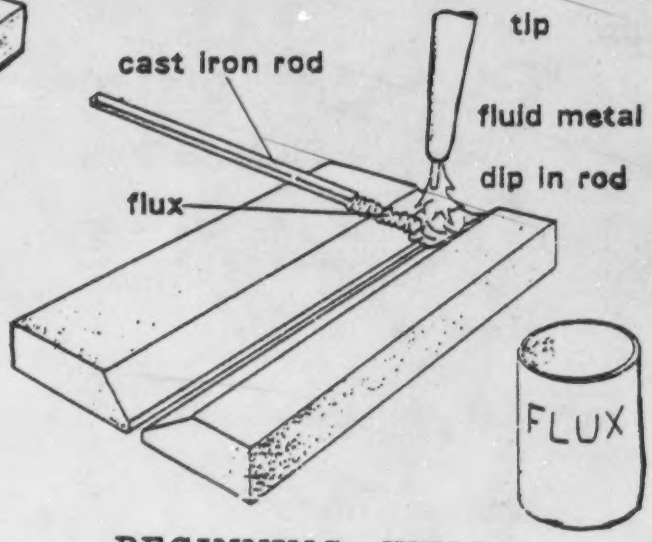


OVERHEAD

WELDING CAST IRON

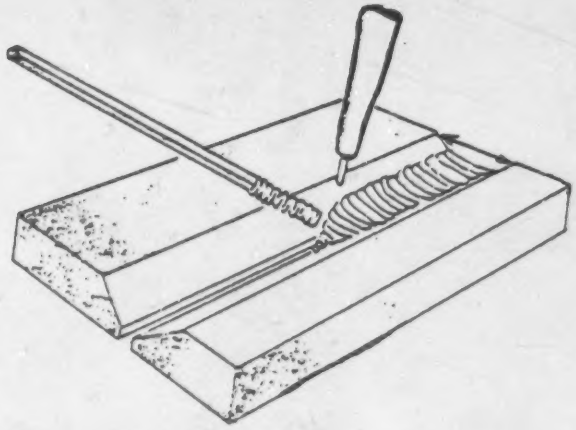


PREHEAT CAST IRON



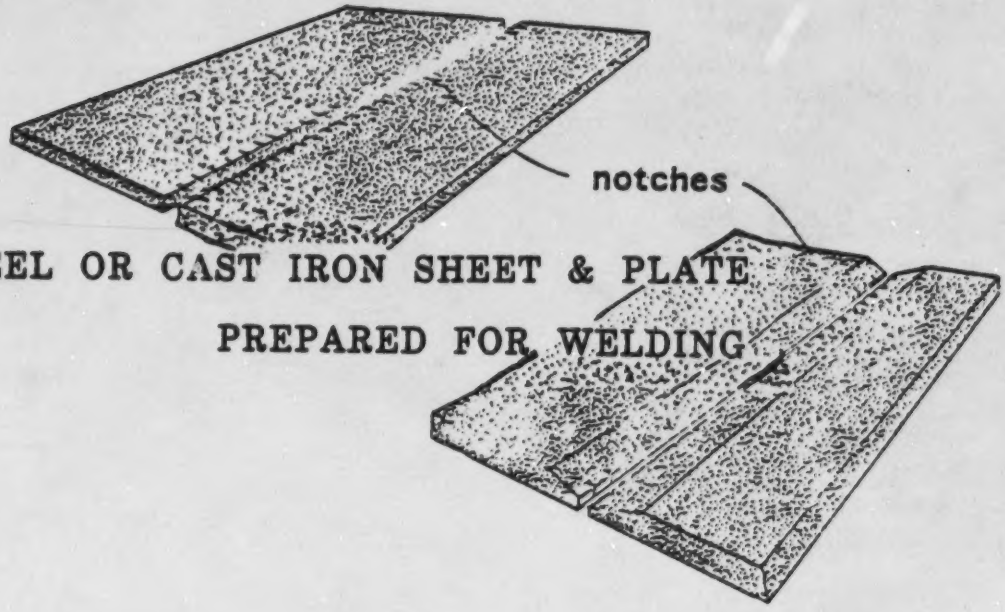
BEGINNING WELD

MULTIPLE PASS WELD

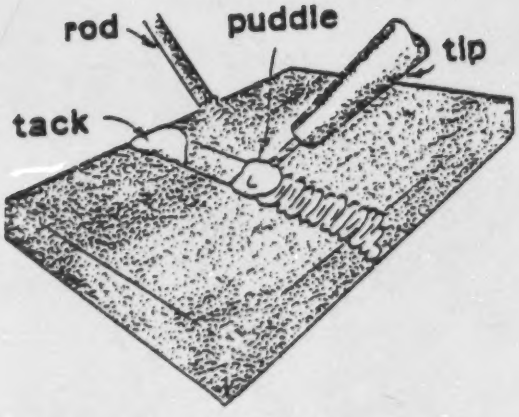


WELDING FIRST PASS

BRONZE WELDING



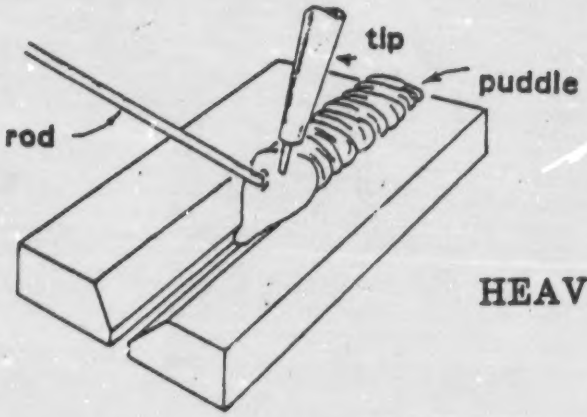
STEEL OR CAST IRON SHEET & PLATE
PREPARED FOR WELDING



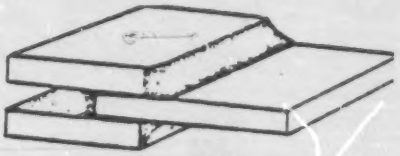
BRONZE WELDING SHEET STEEL

BRONZE WELDING

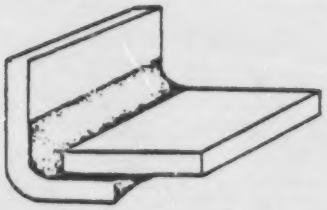
BRONZE WELDING :



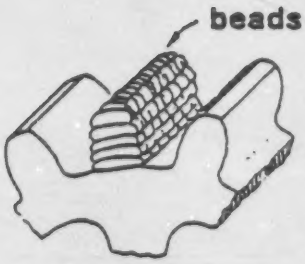
HEAVY STEEL



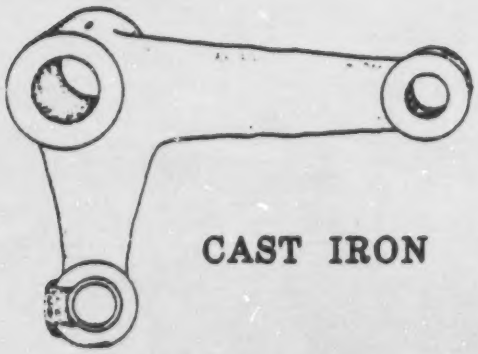
DOUBLE LAP



FLANGED BOTTOM



TOOTH IN GEAR



CAST IRON

Preventive Maintenance

Three Weeks

Instructional tips

1. It is suggested that the three week preventive maintenance unit be taught using the FMO "Preventive Maintenance" Instructor kit (for the teacher) and text books (for the students).
2. Address for purchase of FMO materials:

   John Deere Service Publications
   Department F
   John Deere Road
   Moline, Illinois 61265

   a. Cost of Instructors kit in 1982 - $20.75

   b. Textbooks - Preventive Maintenance in groups of 10 or more are $6.70 in 1982 and $8.95 if ordered in groups less than 10.

Objectives

Upon completion of this unit the student will be able to:

1. Know how to use the operators manual for identifying maintenance activities and intervals.
2. Appreciate the value of preventive maintenance.
3. Perform preventive maintenance activities on the engine lubricating, fuel, cooling, intake, exhaust and electrical systems of modern agriculture equipment.
4. Perform preventive maintenance activities on power trains and hydraulic systems of modern agricultural equipment.
5. Perform tune-up and storage preparation for modern agricultural equipment.
6. Trouble shoot performance on modern agricultural equipment.

Teaching tips

1. Chapters 1 through 8 plus 10 and 11 are important concepts to get across to high school students.
2. It is suggested that even if the unit takes more time than three weeks, to complete the unit. The value of this information to the student as he/she works in production agriculture is very high.
3. Keep the instruction as "hands on" oriented as possible (you may find sections of chapters which you may decide to skip because of time consumed reading.
4. Use tractors from community or local dealers with their Operators' Manuals and allow the students to perform the identified activities.

CEREAL AND FORAGE CROPS

Instructor's Guide

1. This unit was developed to be fairly general in nature. Materials specific to cereal and forage production in your area are available at your Extension Office (i.e. fertilizer recommendations, seeding rates, enterprise practices, etc.).
2. Emphasis should be given to the study of the universal grain and wheat, with other cereal grains being emphasized according to their prominence in your local area.
3. Grain and forage samples should be utilized extensively to help students learn identification and characteristics of common crops.
4. Field trips are necessary for students to grasp the concepts of approved practices for growing grain and forage crops.
5. A land laboratory or other field site allows the use of demonstration sites for cereal and forage crops. Seedbed preparation, seeding, fertilization methods, fertilization rates, variety tests, and harvesting methods can be best taught by "hands on" involvement of students.

Objectives

Upon completion of this unit, the student will be able to:

1. Identify the common cereal grains during growth and as harvested grain.
2. Describe cultural practices for cereal grain production.
3. Identify the common forage crops (local) during growth and as harvested grain.
4. Describe cultural practices for the forage crops identified in Objective #3.
5. Describe the types, growth habits, and utilization of wheat.
6. Describe the types, growth habits, and utilization of alfalfa.
7. Describe the types, growth habits, and utilization of at least two grasses that are predominant in the local area.
8. Identify steps in developing an improved pasture.
9. Prepare a seedbed for cereal and/or forage crop.
10. Seed and fertilize a cereal and/or forage crop.
11. Control weeds in cereal and/or forage crops.
12. Harvest cereal grains and/or forage crops.

Teaching Aids

1. Growing Wheat-General Information Unit, Oregon Ag II Guide.
2. Improving permanent Pasture - General Information Unit, Oregon Ag II Guide.
3. Extension Bulletins included in Oregon Ag II Guide and available from the OSU Extension Service at county offices.

Student Activities

1. Read the objectives for this unit.
2. Study material provided by instructor.
3. Examine grain and forage samples provided by instructor, listing and identifying characteristics of each sample.
4. Visit fields of various cereal and forage crops during growth - as part of field trip or on individual assignments to evaluate growth habits of species and varieties.
5. Participate in preparing a seedbed for cereal and/or forage crops.
6. Assist in fertilization for a cereal and/or forage planting.
7. Assist with weed control in a cereal and/or forage planting.
8. Participate in harvesting a cereal and/or forage crop.

References

1. Variety Recommendations - Local OSU Extension Office.
2. Oregon Insect Control Handbook - Extension Service or OSU Bookstore.
3. Oregon Disease Control Handbook - Extension Service or OSU Bookstore.
4. Oregon Weed Control Handbook - Extension Service or OSU Bookstore.
5. Extension Publications provided in Oregon Ag II Guide and available at OSU Extension Office at county locations.
6. Other appropriate Extension publications for cereal and/or forage crops important in your local area, vocational agriculture teachers should get themselves on mailing lists for Extension materials.

Introduction Ideas

1. It is suggested that you develop an introduction to this unit around the Oregon economic data supplied on the following pages.
2. Up-dates of this data are available each January from:

   Stan Miles
   219 Extension Hall
   Oregon State University
   Corvallis, Oregon 97331

3. Teach only crops information which is pertinent to your local area.

OREGON'S LEADING AGRICULTURAL COMMODITIES

Gross Farm Sales

1981

Rank	Commodity	1981p	1980r	1979
		thousand dollars		
1	Cattle & Calves	304,769	290,000	360,000
2.	Wheat	302,153	301,860	210,254
3.	Dairy	172,466	151,472	133,327
4.	Potatoes	96,999	83,489	63,830
5.	Nursery Crops	91,140	85,500	1/
6.	Alfalfa Hay	49,454	49,171	36,500
7.	Farm Forest	39,100	47,815	50,411
8.	Dry Onions	38,005	30,645	12,366
9.	Chicken Eggs	31,757	27,316	27,035
10.	Perennial Ryegrass	30,020	24,325	21,602
11.	Annual Ryegrass	27,438	23,485	19,291
12.	Barley	26,631	25,812	17,263
13.	Winter Pears	25,929	24,240	26,880
14.	Christmas Trees	25,563	20,610	15,574
15.	Broilers	24,661	23,342	23,251
16.	Peppermint	22,868	24,300	26,163
17.	Sweet Corn, Processed	22,079	17,902	20,216
18.	Sweet Cherries	20,777	15,900	20,672
19.	Snap Beans, Processed	20,647	24,714	26,380
20.	Sheep & Lambs	20,000	16,142	16,500
21.	Strawberries	19,918	15,333	14,370
22.	Hops	18,475	17,371	9,228
23.	Hogs	17,254	16,309	15,827
24.	Greenhouse Crops	17,115	14,899	1/
25.	Apples	15,532	14,820	18,700
26.	Filberts	13,920	17,380	12,078
27.	All Kentucky Bluegrass	11,170	11,642	10,214
28.	Turkeys	10,774	10,004	10,552
29.	Horses	10,166	7,447	6,918
30.	Sugarbeets for Sugar	8,800	9,176	4,550
31	Dry Field Beans	8,561	5,656	2,280
32.	Green Peas	8,478	9,363	7,595
33.	Oats	8,081	6,319	4,681
34.	Corn for Grain	8,072	2,436	2,114
35.	Bartlett Pears	7,373	13,600	14,620
36.	Hay (Other than alfalfa)	7,066	7,500	6,252
37.	Mink	6,669	5,958	5,620
38.	Bentgrass	6,498	6,854	8,550
39.	Sugarbeets for Seed	6,470	4,312	3,010
40.	Red Raspberries	5,791	2,979	6,820

p - Preliminary. r - Revised. 1/ not estimated separately.

Rank	Commodity	1981p	1980r	1979
		thousand dollars		
41.	Red Clover	4,967	4,032	3,940
42.	Vegetables and Flower Seed	4,611	3,688	4,223
43.	Orchardgrass	4,556	6,792	6,120
44.	Chewings Fescue	4,489	7,075	5,184
45.	Tame Blackberries	4,419	5,875	8,162
46.	Turf Sod	4,340	5,215	1/
47.	Corn Silage	4,153	4,527	3,943
48.	Red Fescue	3,846	4,200	3,848
49.	Cranberries	3,553	2,722	2,523
50.	Prunes & Plums	3,527	4,983	4,784
51.	Peaches	3,480	2,899	3,072
52.	Bulbs	3,425	3,195	2,893
53.	Alfalfa Seed	3,366	5,415	5,166
54.	Cucumbers, Processed	2,907	2,712	2,374
55.	Crimson Clover	2,846	1,433	2,300
56.	Grapes	2,835	2,091	1,734
57.	Wool	2,797	3,220	3,210
58.	Squash & Pumpkins	2,584	2,029	1,800
59.	Blueberries	2,538	1,400	1,572
60.	Tall Fescue	2,518	2,618	1,872
61.	Cauliflower, Processed	2,480	2,895	2,381
62.	Dry Field Peas	2,469	2,628	2,613
63.	Cabbage	2,421	2,094	1,620
64.	Turkey Eggs	2,346	2,459	2,154
65.	Sweet Corn, Fresh	2,216	2,225	2,138
66.	Beets, Processed	2,011	1,927	2,067
67.	Lettuce	1,958	1,862	1,667
68.	Cauliflower, Fresh	1,811	1,500	1,254
69.	Carrots, Fresh	1,680	2,086	910
70.	Tart Cherries	1,639	1,015	1,519
71.	Broccoli, Processed	1,634	1,437	1,200
72.	Watermelon	1,570	1,280	885
73.	Spearmint for Oil	1,535	1,470	1,453
74.	Austrian Peas	1,348	1,254	1,613
75.	Honey & Beeswax	1,305	1,264	1,196
76.	Hairy Vetch	1,263	868	1,900
77.	Garlic	1,242	1,288	1,069
78.	Tomatoes	1,235	925	969
79.	Walnuts	1,225	1,425	1,444
80.	Boysenberries	1,185	1,064	1,873
81.	Pinto Beans	1,126	1,650	n/a
82.	Asparagus	1,119	582	527
83.	White Clover & Ladino	1,085	1,037	772
84.	Carrots, Processed	1,038	925	1,086
85.	Rabbits	1,027	1,011	716
Other commodities		39,602	41,738	117,590 2/
TOTAL GROSS FARM SALES		1,759,966	1,663,428	1,512,830

p - Preliminary. r - Revised.

1/ not estimated separately.

2/ includes nursery crops, greenhouse crops and turf sod.

SOURCE: Compiled by Extension Economic Information Office, Oregon State University.

OREGON GROSS FARM SALES
Preliminary 1981 Estimates

District & county	Grains	Hay & silage	Grass & legume seeds	Field crops	Tree fruits & nuts	Small fruits & berries	All vegetable crops	Specialty products	All crops	Cattle & calves	Dairy products	Eggs & poultry	Misc. animals	All livestock & products	Total gross income
	thousand dollars														
The State....	345,203	61,941	106,797	173,105	96,462	38,903	123,574	202,403	1,148,388	304,769	172,466	67,695	66,648	611,578	1,759,966
District 1...	62,556	8,127	91,323	41,976	30,012	33,127	85,067	162,968	515,156	34,775	78,505	60,245	31,453	204,978	720,134
Benton.....	4,495	468	7,005	2,494	759	725	4,621	7,325	27,892	1,890	3,780	209	1,337	7,216	35,108
Clackamas..	4,945	796	3,144	1,042	2,681	5,193	10,794	37,880	66,475	4,935	6,950	20,602	8,633	41,120	107,595
Lane.....	4,156	353	4,922	4,159	3,128	821	6,621	11,250	35,410	6,518	7,440	7,368	1,886	23,212	58,622
Linn.....	7,615	1,000	45,700	5,517	922	1,477	5,209	5,644	73,138	5,682	8,813	4,835	6,932	26,262	99,400
Marion.....	10,944	1,569	16,123	23,574	5,446	10,526	37,144	40,020	145,346	5,854	23,487	10,165	4,735	44,240	189,586
Multnomah..	556	81	98	352	144	3,523	6,347	21,297	32,398	745	1,623	10	561	2,939	35,337
Polk.....	10,787	723	5,309	3,123	3,835	863	1,712	5,545	31,897	2,497	5,167	4,537	1,655	13,856	45,753
Washington.	7,227	1,966	5,019	1,271	6,067	9,945	7,514	24,945	63,054	3,042	12,065	580	2,069	17,756	80,810
Yamhill....	11,831	1,105	3,918	444	7,120	954	5,112	9,062	39,546	3,612	9,180	11,939	3,646	28,377	67,923
District 2...	537	436	40	60	39	5,041	171	13,692	20,016	16,912	54,968	293	6,152	78,325	98,341
Clatsop....	---	66	---	---	---	58	5	1,900	2,029	1,193	2,046	8	1,874	5,121	7,150
Columbia...	537	132	40	38	21	1,320	76	3,700	5,864	3,037	2,984	8	450	6,479	12,343
Coos.....	---	99	---	---	13	3,220	10	2,677	6,019	4,873	11,583	249	1,438	18,143	24,162
Curry.....	---	18	---	---	5	341	---	2,390	2,754	1,546	891	5	1,012	3,454	6,208
Lincoln....	---	27	---	---	---	53	50	1,725	1,855	1,097	314	23	359	1,793	3,648
Tillamook..	---	94	---	22	---	49	30	1,300	1,495	5,166	37,150	---	1,019	43,335	44,830
District 3...	2,428	1,549	572	1,402	16,357	452	1,889	14,338	38,987	21,492	14,892	4,187	7,465	48,036	87,023
Douglas....	1,435	494	153	36	2,411	425	1,416	8,250	14,620	10,679	1,286	647	5,071	17,683	32,303
Jackson....	941	762	419	198	13,706	27	377	3,154	19,584	8,485	5,945	3,404	1,713	19,547	39,131
Josephine..	52	293	---	1,168	240	---	96	2,934	4,783	2,328	7,661	136	681	10,806	15,589
District 4...	219,732	13,618	1,142	60,293	48,301	267	13,036	5,710	362,099	48,449	1,691	2,168	8,861	61,169	423,268
Gilliam....	22,804	269	234	173	---	---	---	10	23,490	4,327	---	---	195	4,522	28,012
Hood River.	---	135	---	---	31,484	99	85	770	32,573	732	507	364	449	2,052	34,625
Morrow.....	49,476	6,830	---	36,900	99	---	137	1,550	94,992	8,923	436	---	1,422	10,781	105,773
Sherman....	32,306	54	---	40	15	---	---	---	32,415	1,813	---	1,795	127	3,735	36,150
Umatilla...	91,238	5,570	908	23,056	5,857	168	12,712	2,830	142,334	23,432	748	6	5,314	29,500	171,839
Wasco.....	23,404	698	---	---	10,846	---	102	400	35,450	5,740	---	3	1,051	6,794	42,244
Wheeler....	504	62	---	124	---	---	---	150	840	3,482	---	---	303	3,785	4,625
District 5...	38,957	7,107	7,676	34,445	1,474	16	22,994	2,030	114,699	84,682	15,074	24	4,679	104,459	219,158
Baker.....	3,553	1,202	43	170	20	---	---	360	5,348	18,051	2,422	3	832	21,308	26,656
Malheur....	16,268	4,012	2,202	32,503	243	16	22,967	100	78,311	51,262	11,887	10	1,493	64,652	142,963
Union.....	13,420	793	5,431	692	1,211	---	---	870	22,417	5,111	610	8	1,442	7,171	29,588
Wallowa....	5,716	1,100	---	1,080	---	---	27	700	8,623	10,258	155	3	912	11,328	19,951
District 6...	20,993	31,104	6,044	34,929	279	---	417	3,665	97,431	98,459	7,336	78	8,038	114,611	212,042
Crook.....	1,376	6,615	150	2,859	---	---	8	250	11,258	12,688	575	31	492	13,786	25,044
Deschutes..	619	1,901	113	1,253	---	---	---	950	4,836	4,215	2,371	20	1,716	8,322	13,158
Grant.....	433	882	---	374	279	---	---	1,260	3,228	9,709	---	40	1,808	11,557	14,785
Harney.....	1,110	2,848	36	132	---	---	---	10	4,136	19,207	---	---	501	19,708	23,844
Jefferson..	7,296	1,785	5,697	12,074	---	---	409	175	27,436	9,443	---	3	1,227	10,673	38,109
Klamath....	8,412	10,088	20	17,885	---	---	---	900	37,305	26,527	4,315	684	1,693	33,219	70,524
Lake.....	1,747	6,985	28	352	---	---	---	120	9,232	16,670	75	---	601	17,346	26,578

SOURCE: Compiled by Extension Economic Information Office, Oregon State University.

December 1981

HARVESTED ACREAGE SUMMARY*

Oregon Counties, 1981

Counties	Grains	Hay & forage	Grass & leg seeds	Field crops	Tree Fr & nuts	Sm Fru & ber	All Veg crops	Spec. Products	Total
State Total	1,613,000	1,018,550	339,340	155,790	79,589	15,549	125,320	2,432	3,450,512
District 1	327,800	175,100	302,030	36,170	40,803	13,888	84,954	2,032	983,702
Benton	22,400	11,900	23,600	2,850	628	225	6,806	540	68,955
Clackamas	33,300	26,200	11,100	590	3,720	2,705	5,710	520	83,845
Lane	24,300	23,300	16,660	5,730	3,800	335	9,142	100	83,365
Linn	40,800	26,400	148,950	7,665	855	550	6,940	122	232,292
Marion	54,900	22,300	45,050	15,230	6,500	4,725	41,444	270	190,415
Multnomah	3,900	3,300	400	250	140	1,300	2,475	10	11,780
Polk	54,600	14,700	21,240	2,390	5,580	433	2,795	340	102,085
Washington	35,100	25,000	18,000	1,085	10,020	3,100	3,432	100	96,740
Yamhill	58,500	22,000	17,030	380	9,560	515	6,210	30	114,225
District 2	3,550	37,300	245	90	32	1,363	120	70	42,770
Clatsop	---	4,000	25	---	---	---	---	---	4,025
Columbia	3,550	8,800	220	70	32	480	120	50	13,320
Coos	---	12,500	---	---	---	748	---	10	13,260
Curry	---	2,500	---	---	---	91	---	---	2,590
Lincoln	---	3,000	---	---	---	30	---	10	3,040
Tillamook	---	6,500	---	20	---	14	---	---	6,535
District 3	15,650	84,100	750	1,265	12,906	168	1,060	150	116,060
Douglas	10,400	47,300	270	55	2,100	155	805	90	61,185
Jackson	4,900	27,600	480	260	10,635	13	213	40	44,145
Josephine	350	9,200	---	950	171	---	42	20	10,730
District 4	952,100	124,100	2,510	45,860	24,704	125	27,826	150	1,177,375
Gilliam	139,500	7,600	480	430	---	---	---	---	148,010
Hood River	---	2,150	---	---	15,210	45	26	---	17,435
Morrow	224,750	30,700	---	27,350	40	---	80	150	283,070
Sherman	151,750	950	---	250	12	---	---	---	152,960
Umatilla	335,800	57,700	2,030	17,730	3,605	80	27,697	---	444,650
Wasco	96,600	13,000	---	---	5,837	---	23	---	115,460
Wheeler	3,700	12,000	---	100	---	---	---	---	15,800
District 5	187,300	231,100	16,285	42,100	1,010	5	11,080	---	488,885
Baker	21,300	72,600	150	330	20	---	---	---	94,400
Malheur	59,500	97,500	5,250	38,870	140	5	11,020	---	212,285
Union	69,000	31,000	10,885	2,500	850	---	---	---	114,240
Wallowa	37,500	30,000	---	400	---	---	60	---	67,960
District 6	126,600	466,850	17,520	30,305	134	---	280	30	641,720
Crook	4,900	49,000	550	2,920	---	---	---	---	57,370
Deschutes	3,650	22,700	370	1,050	---	---	---	---	27,770
Grant	2,850	46,000	---	630	134	---	---	---	49,610
Harney	16,600	131,000	1,500	120	---	---	---	---	149,220
Jefferson	30,350	17,150	15,020	15,955	---	---	280	30	78,790
Klamath	43,150	71,000	---	9,000	---	---	---	---	123,150
Lake	25,100	130,000	30	630	---	---	---	---	155,810

*Acreage estimates are not included for many specialty crops, pastures and rangeland areas.

SOURCE: Compiled by Extension Economic Information Office, Oregon State University. December 1981

GROWING WHEAT

1. What Factors Should I Consider Before Selecting a Variety?
2. What Practices Are Recommended For Growing Winter Wheat?
3. What Insects and Diseases Attack Growing Wheat?

Wheat is the most important crop in the world. The chief producing countries are the U.S.S.R., the United States, China, India, France, and Canada. Wheat is grown commercially in 42 states in the U.S. Concentrated acreages occur in the Ohio Valley, Central and Northern Plains, and Pacific Northwest. The leading states in approximate order of acreage seeded are Kansas, North Dakota, Illinois, Missouri, Idaho, Ohio, Indiana and Oregon. Oregon is 15th in acre seeded. The average yield for wheat in the United States was 33 bushels per acre in 1980. Oregon's average yield in 1980 was 57 bushel/acre, with a total production of over 77 million bushels and total value over 300 million dollars. The highest authentic yield is 209 bushels per acre on a 2.2-acre, well fertilized, irrigated field in Kittites County, Washington, in 1965.

Eighty percent of the wheat grown in Oregon is exported and used outside of the state. Oregon wheat producers continue to explore markets outside of the United States.

Very little spring wheat is grown except when unfavorable weather in the fall prevents the seeding of winter wheat and when winter wheat freezes out.

Since spring wheat usually yields less than three-fourths as much as winter wheat, this preference seems to be fully justified.

Uses of wheat

Wheat is grown because it is a good cash grain crop. It may be used for grazing livestock, as a hay crop, or seeded to stabilize the soil and retard food but may also be fed successfully to all classes of farm animals. The crop fits well in many rotations or cropping systems and can be used as a companion crop underseeded to legumes and grasses.

Wheat enters many food preparations. It is best known as the principal ingredient in many kinds of breads, cakes, cookies, crackers, breakfast cereals, and macaroni. It is also an ingredient in pancakes, noodles, pie crust, puddings, ice cream cones, pizza, and baby food. Wheat germ, bran, flour, and malt are special portions or parts of the wheat grain that appear in food items. Wheat is used in gravies, sauces, soups, candies, and beverages. The stalks and heads, often brightly colored, appear in floral bouquets.

Adaptation

In areas with high rainfall and under irrigation, wheat is commonly grown in rotations with potatoes, clovers, or grasses. Alfalfa is also used in long-term rotations with wheat. Soils capable of pro-

ducing satisfactory yields of these crops are well adapted for wheat. In areas of low rainfall, wheat is commonly grown continuously on the land. Often a year of "gallow" is necessary between crops. Like other small grains, wheat yields best on medium to heavy textured, well drained soils with well balanced fertility. High nitrogen content in the soil, in relation to other nutrients, causes excessive negative growth and lodging in weak-strawed varieties and makes the plants susceptible to several diseases. Wheat is not a satisfactory crop on poor, sandy soils or on poorly drained soils. Highly acid soils sometimes cause high levels of aluminum toxicity to wheat. Under these conditions, use tolerant varieties and add lime. Barley tolerates soil alkalinity better than wheat.

Variety, adaptation, production practices, pest control, and local climate and soil conditions are closely related. For this reason, the United States is divided into six regions for ease of discussion (Fig. 1).

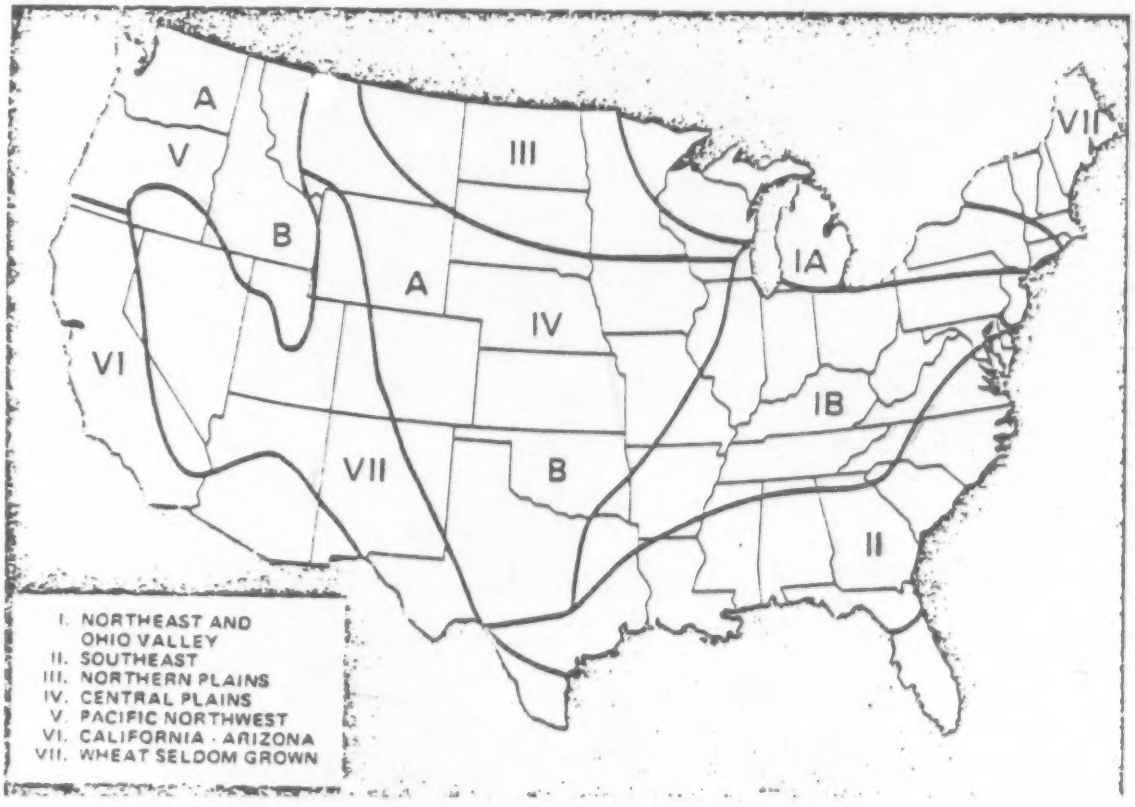


Fig. 1. Adaptation regions for wheat.

Kinds of wheat

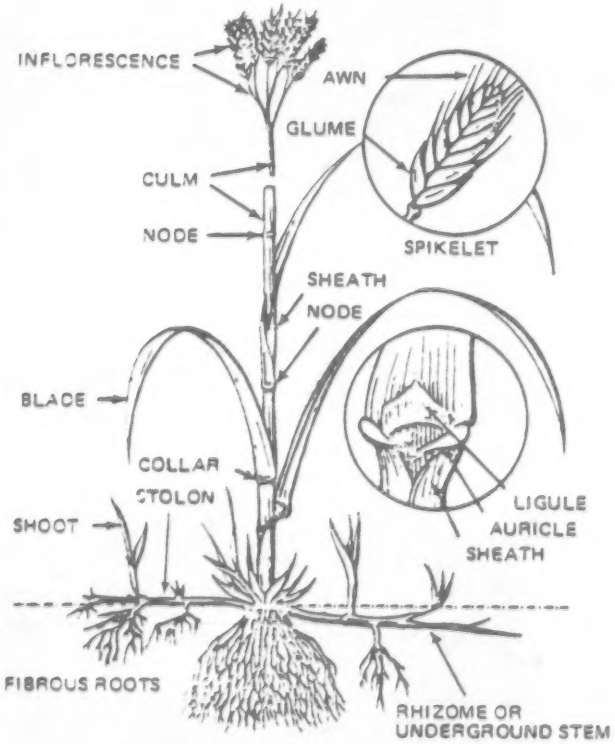
All wheat is not alike. Special uses are recognized for different kinds. The place and the way each kind is grown may be entirely different. Marketing practices are also influenced. Wheat can be grouped into kinds in several ways.

The Official Grain Standards of the United States defines market wheat as the grain of Common wheat, Club wheat, and Durum wheat which, before the removal of the dockage, consists of 50 percent or more of one or more of these wheats and not more than 10 percent of other grains.

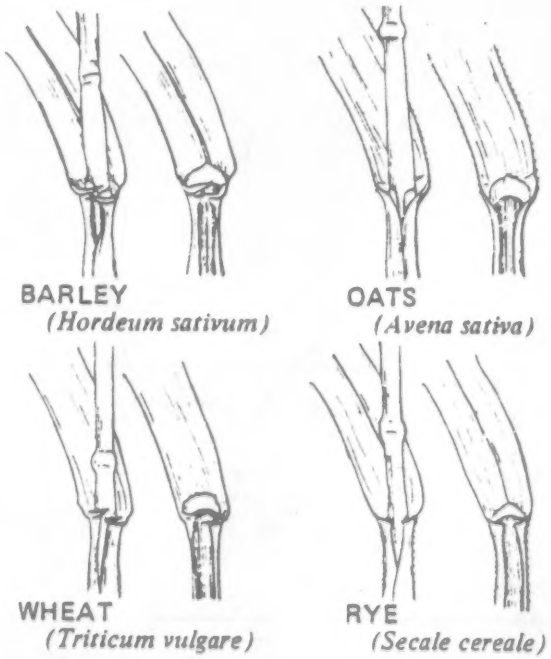
The market classes of wheat are Hard Red Winter, Hard Red Spring, Soft Red Winter, White (including Club), Amber Durum, Red Durum, and Mixed. Most wheat grown in Oregon is white wheat used in pastry and noodles.

Dr. Warren Kronstad of Oregon State University developed a variety of white wheat called "Stevens Wheat" which has significantly increased wheat yields in the Pacific Northwest.

The grain of hard red winter wheat is generally hard in texture and high in protein. Flour from the processed grain is suitable for bread. The grain of soft red winter wheat is soft in texture and the flour is suitable for cake, pastries, and general purposes. Therefore, care should be taken not to mix the two.



Principal parts of a grass plant.



By looking at the auricles, ligules, and leaves you should be able to identify young cereal plants. Barley has long clasping auricles; Wheat has shorter hair auricles; Rye has very short auricles; and Oat sheath does not have auricles. The shapes of the ligules are also different.

1. WHAT FACTORS SHOULD I CONSIDER BEFORE SELECTING A VARIETY?

Over 200 varieties of wheat are grown on a commercial scale in the United States. Some have red grain, others have white; some have beards (awns), and others are beardless. They differ greatly in color of chaff and straw, in height, and especially in such important characteristics as winter hardiness, yield, quality, resistance to lodging, and ability to tiller.

Because of the large number of varieities available and their great variation in these characteristics, the choice of the best variety for a particular farm is often difficult. For example: Are some varieties more resistant to poor drainage conditions? Should disease resistance be considered? Are there important differences in quality, or is it sufficient to know that a given variety can be depended upon to give satisfactory yield? As a grower, you should consider these and other questions.

Yield is the characteristic by which a variety is most commonly judged. No variety may be considered satisfactory unless its yield is good in comparison with other varieties. However, yielding ability, or the tendency to produce a generally satisfactory yield over a period of years, is a difficult characteristic to judge. One reason for this is the variation in weather and disease outbreak from year to year. Thus, a new variety may produce a good yield for 2 or 3 years, but may later prove to be unsatisfactory because of susceptibility to winterkilling, disease, or other damage. It is a good policy to be skeptical of new, untried varieties. To determine whether a given variety is a good yielder, it must be grown for a number of years, preferably in direct comparison with other wellknown standard varieties. This kind of evidence is gathered by agricultural experiment stations, where information should be sought if there is doubt as to the value of a variety. Your Oregon State University Extension Agent can help with the selection of a variety appropriate to your soil and climactic conditions.

Some people like to debate the bearded versus beardless issue. However, there is considerable evidence to show that the beards aid in the filling of the grain to the point that bearded wheats tend to have more plump grain than do beardless varieties. Some wheat breeders also feel that bearded wheat has stronger stalks and is more drought resistant. This is not always the case though. It is advisable to depend upon performance records and yields when choosing varieties.

A satisfactory winter wheat must be sufficiently hardy to survive winters of average or above average severity in the locality where is is to be grown. Winters fluctuate greatly in this respect. Low temperatures, especially when accompanied by loose dry soil conditions and the absence of snow cover, may cause extensive killing and crop loss.

Winterkilling may also be due to heaving as a result of the alternate freezing and thawing of the soil in late winter. In this process, ice lifts the plants and the roots are broken and exposed. The plants may be damaged or killed. Sometimes standing water, or ice, smother the plants. Winterkilling is often the combined result of these types of injury and disease.

With ideally conditions throughout the growing season, late-maturing varieties should produce the highest yields. Usually; however, conditions are not favorable throughout the season. Rust, scab, powdery mildew, Septoria, and other diseases appear in late spring; and in some areas the high temperatures of early summer and drought are unfavorable for growth. On poor soils the supply of mineral elements may be insufficient to carry a late crop to maturity in the most satisfactory manner. For these reasons, early maturing varieties usually produce better yields than those that require a long growth period.

Ability to resist lodging is very important in choosing a variety, especially under conditions of heavy nitrogen fertilization, where lodging frequently occurs. The general use of the combine for harvesting has made strong straw especially important, since the harvest is delayed one or more weeks so the grain will be dry enough to store. Lodged grain is difficult and expensive to harvest. Lodging that occurs early generally interferes with the filling of the heads. This often results in a low yield of grain, with low test weight, and poor quality. Varieties differ greatly in resistance to lodging; semidwarf types are very resistant. The trend in the development of varieties for the future is toward shorter and stronger straw.

Wheat suffers from many diseases. The most significant diseases are stem rust, leaf rust, Septoria leaf and glume blotch, stripe rust, powdery mildew, loose smut, bunt (stinking smut), mosaic, and scab. Bunt and loose smut can be prevented by seed treatment, but this requires special equipment.

Diseases, in general, are best controlled by growing resistant varieties. Use of resistant varieties is desirable if they are satisfactory in other respects.

2. WHAT PRACTICES ARE RECOMMENDED FOR GROWING WINTER WHEAT?

Fertilization

In most areas commercial fertilizers and manure may be used to good advantage in growing the wheat crop. The best fertilizer combination to use on wheat, or in a rotation containing it, depends largely on the soil type and productivity of the soil. Productivity is related to the nature of the soil, its previous treatment, and climatic conditions. Have a soil test done at the Oregon State University Soil Testing Service and follow the fertilizer recommendation for your particular field. Other, generalized, fertilizer recommendations are available from the Extension Agent, and are included with this instructional unit; however, a soil test will yield the most accurate recommendation.

Nitrogen deficiency can be corrected by plowing under crops of legumes, adding manure, or applying commercial fertilizer. When wheat plants have light-green foliage, it usually indicates a shortage of available nitrogen, although disease may be the cause.

Innoculated legumes fix uncombined nitrogen from the air. The amount of nitrogen (up to 50 to 100 pounds per acre) added to the

soil depends on the kind of legume grown and the type of management program followed. Generally, when more top growth is turned under, more nitrogen is added. Nonleguminous crops, such as wheat, depend on nitrogen derived from decomposition of soil organic matter and manure, or from applied chemical fertilizers.

Manure is a valuable fertilizer and soil conditioner for wheat. On both light sandy soils and heavy clay soils, application of well-rotted manure supplies humus which improves the physical condition of the soil and also adds valuable nutrients, particularly nitrogen and potash.

Commercial fertilizer is generally applied to wheatland at seeding time by an attachment to the grain drill. A complete chemical fertilizer is most often used. Additional amounts of nitrogen may be added in the spring as a top dressing, especially on sandy soils. The fertilizer formula and the rate of application will vary with locality, soil type, and cropping history.

Also remember that time and rate of fertilizer application have an effect on the protein content of the wheat crop harvested. With the advent of shorter and stronger strawed varieties, farmers are currently using heavier rates of application. Frequently available nitrates in the soil are still plentiful when the wheat plants reach the heading stage. Under these conditions more nitrogen than usual is stored in the kernel in theform of protein, and a high protein grain crop is produced. If the wheat crop is topdressed with nitrogen in early spring, generally the protein content of the ensuing grain crop is not affected. However, if the rate of application is unusually heavy, or if the nitrogen is not applied until near heading time, the protein content of the grain can also increase. High protein content is desirable in hard wheats, but not in the soft wheats processed through conventional milling procedures.

Oregon State University Fertilizer Guide

Extension Service, Oregon State University, Henry A. Wadsworth, director. This publication was produced and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. Extension work is a cooperative program of Oregon State University, the U.S. Department of Agriculture, and Oregon counties. Extension invites participation in its programs and offers them equally to all people.

FG 9
Revised January 1977

WINTER WHEAT

(Western Oregon - West of Cascades)

Good management practices are essential if optimum fertilizer responses are to be realized. These practices include use of recommended varieties, selection of adapted soils, weed control, disease and insect control, good seed bed preparation, proper seeding methods, and timely harvest.

Because of the influence of soil type, climatic conditions, and cultural practices, crop response from fertilizer may not always be accurately predicted. Soil test results, field experience, and knowledge of specific crop requirements help determine the nutrients needed and the rate of application.

Recommended soil sampling procedures should be followed in order to estimate fertilizer needs. Your county agent can provide you with soil sampling instructions, soil sample bags and information sheets.

This guide is for Yamhill, Hyslop, McDermid, Stephens, Nugaines and similar high yielding varieties with which yields of 100 bu/A (3 tons) or more can be expected on well adapted soils.

NITROGEN (N)

Fall Application

1. Apply 20 lbs N/A at seeding time where wheat follows grass or grain.

   Where straight N fertilizers or ammonium sulfate are used, the fertilizer can be banded or broadcast. Where N is applied in a fertilizer which also contains P, a banded application is recommended.

2. Fall application of N is not recommended where wheat follows a heavily fertilized row crop or legume.

Spring Application

1. Apply between late February and mid-March.

   No advantage has been observed from splitting spring N application.

2. Apply 150 lbs N/A where wheat follows grain or grass.

3. Apply 70 to 100 lbs N/A where wheat follows vetch peas, or a poor stand of perennial legumes or is the second crop following good perennial legumes.

4. Apply 40 to 70 lbs N/A where wheat follows a good crop of perennial legumes or crimson clover.

5. The rate of N application can be reduced when residual N from a previous heavily fertilized horticultural crop is present in the soil. N responses will vary with variety, soil, locality, and weather conditions.

To increase yields - 2 1/2 to 3 lbs of added N are required for each additional bushel where N is limiting. Experienced growers can use this information to adjust N rates for maximum economic yields.

Example - If the estimated yield is 80 bu/A with 60 lbs of N applied; it should take about 55 lbs more N/A to increase the yield to 100 bu/A if the other factors are not limiting.

Under irrigation, winter wheat might respond to a higher application of N in the spring.

Yamhill is adapted to a range of soil acidity and drainage conditions and should be seeded in preference to other varieties on the more acid and the more poorly drained soils. On well drained, fertile soils Hyslop, McDermid, Stephens, or Nugaines have given higher yields than Yamhill.

PHOSPHORUS (P)

If the OSU soil test for P reads (ppm):	Apply this amount of phosphorus (P_2O_5)-lbs/A:
A. Willamette Valley and Northwest Oregon.	
0 to 10	40-60
10 to 25	30-40
Over 25	None
B. Southwest Oregon	
0 to 10	40-60
10 to 15	30-40
Over 15	None

The P content of fertilizer is expressed as the oxide (P_2O_5) on fertilizer labels. Multiply P_2O_5 by 0.44 to convert to P. Band close to the seed.

Broadcast applications of P are less effective. When broadcasting P use double the rate recommended above and work into the soil prior to seeding.

POTASSIUM (K)

If the OSU soil test for K reads (ppm):	Apply this amount of potassium (K_2O)-lbs/A:
0 to 75	60-100
75 to 100	30- 60
Over 100	None

The K content of fertilizer is expressed as the oxide (K_2O) on fertilizer labels. Multiply (K_2O) by 0.83 to convert to K.

K should be applied before seeding and worked into the seedbed. Banding K has reduced yields under some conditions.

With soil test values for K of 150 ppm or less, it is desirable to repeat soil test every year to indicate when additional K is needed.

SULFUR (S)

Plants absorb S in the form of sulfate. Fertilizer materials supply S in the form of sulfate and elemental S. Elemental S must convert to sulfate in the soil before the S becomes available to plants. The conversion of elemental S to sulfate is usually rapid for fine ground (less than 40 mesh) material in warm, moist soil.

The S requirements of winter wheat can be provided by:

1. The application of 10-15 lbs S/A in the form of sulfate at planting time.
2. Applying 30-40 lbs S/A as fine ground elemental S the preceding year.
3. Applying coarser ground elemental S at higher rates and less frequently.

Responses to S fertilization may not occur for a period of at least 4 or 5 years on "red hill" soils which have a history of high S fertilization. These soils have a comparatively high ability to adsorb S and frequently have a history of high S fertilization through the use of S-containing fertilizer such as ammonium sulfate.

Some S fertilizer materials such as elemental S and ammonium sulfate have an acidifying effect on soil.

MAGNESIUM (Mg)

Responses of winter wheat to Mg have not been observed in western Oregon. Trial applications of Mg are suggested where soil test levels are below 0.5 meq/100g soil.

Mg can be banded at 10 to 15 lbs/A at planting. Mg can also be supplied in dolomite which is a liming material that reduces soil acidity to about the same degree as ground limestone. Dolomite should be mixed into the seed bed at least several weeks in advance of seeding.

An application of dolomite will supply magnesium and reduce soil acidity for several years.

MICRONUTRIENTS

To date there has been no observed response from applications of micronutrients such as boron and zinc to wheat in western Oregon.

LIME

Winter wheat is tolerant of moderately acid soil conditions. Yamhill wheat is especially tolerant of aluminum concentrations associated with low pH and acid hill soils. Wheat yields are not necessarily increased by liming at the higher OSU SMP Buffer readings.

The application of lime is not suggested if the soil pH is 5.5 or higher. The rate of lime application can be estimated from the following OSU SMP Buffer table.

If the OSU SMP Buffer test for lime reads:	Apply this amount of lime (T/A):
below 5.2	4 - 5
5.2 - 5.5	3 - 4
5.5 - 5.8	2 - 3
5.8 - 6.2	1 - 2
Over 6.2	0

The liming rate is based on 100-score lime. Lime should be mixed into the seedbed at least several weeks before seeding. A lime application is effective over several years.

Some soils may have a fairly high OSU SMP buffer value (over 6.2) and a low pH (below 5.3). This condition can be caused by the application of acidifying fertilizer. In this case the low pH value is temporary and the pH of the soil will increase as the fertilizer completes its reaction with the soil. This temporary "active" acidity from fertilizer is encountered following recent applications of most nitrogen fertilizer materials. Acidifying fertilizers also have a "long term" acidifying effect on soil which is cumulative and leads to lower OSU SMP buffer readings.

Sandy soils to which fertilizers have not been recently applied sometimes record low pH and high SMP buffer values. In such cases, a light application of lime (1 to 2 T/A) should suffice to neutralize soil acidity.

For acid soils low in Mg (less than 0.5 meq Mg/100g of soil) one ton/A of dolomite lime can be used as a Mg source. Dolomite and ground limestone have about the same ability to neutralize soil acidity.

P, K, Mg, and lime recommendations are based on soil test values from the Soil Testing Laboratory, OSU, Corvallis, Oregon.

This fertilizer guide is based on experiments conducted by T. L. Jackson, Wilson H. Foote, S. Roberts, and Warren E. Kronstad, Oregon Agricultural Experiment Station, and trials conducted by western Oregon Extension Agents, Hugh Gardner, and Norman Goetze.

Prepared by E. Hugh Gardner and T. L. Jackson, Soil Science, and Norman Goetze and Warren Kronstad, Agronomic Crop Science, OSU Extension Service and Agricultural Experiment Station.

Reviewed by a committee from the Oregon Agricultural Experiment Station and western Oregon County Extension Agents.

OREGON STATE UNIVERSITY EXTENSION SERVICE

Oregon State University Fertilizer Guide for

Extension Service, Oregon State University, Henry A. Wadsworth, director. This publication was produced and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. Extension work is a cooperative program of Oregon State University, the U.S. Department of Agriculture, and Oregon counties. Extension invites participation in its programs and offers them equally to all people.

FG 54
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WINTER WHEAT

(Non-Irrigated--Columbia Plateau)

The response of wheat to fertilizer depends on *good crop management such as weed and pest control and use of recommended varieties, seeding and tillage practices.*

The fertilizer practices suggested in this fertilizer guide are based on trials conducted during 1969-74 in the Columbia Plateau on wheat grown in a wheat-summer fallow rotation.

NITROGEN (N)

N is the plant nutrient which usually most severely restricts dryland wheat yields in the Columbia Plateau. The amount of N fertilizer which should be applied depends on the wheat yield, the amount of soil N available to the crop, and the wheat variety. Where available soil moisture is comparatively high the potential for a high yield of wheat and thus greater N requirement exists. Some types of wheat, such as the club wheats and hard red winter wheats, have a higher N requirement than the semi-dwarf wheats.

Soil Test Value for N

Soil samples should be taken to a depth of 6 feet or, on shallower soils, the depth of root penetration.

Soil samples should be taken from the 0-2' and 2-6' soil depths on deep soils. The soil samples should consist of soil cores removed from the entire 0-2 feet and 2-6 feet depth of soil. On soils shallower than 6' soil samples should be taken from 0-2' and from 2' to the rooting depth.

It is important to follow correct soil sampling procedures as outlined in OSU Extension Circular 628. This publication is available from County Extension Offices.

Soil samples for N analysis are normally taken from summer-fallow ground in the spring prior to fertilizer application.

OSU soil test results for N are reported in ppm. 1 ppm N in a 1 foot depth of soil equals 4 lbs. N/acre.

As an example:

Soil Depth (ft)	Soil Test N ppm	lbs/A
0-2	4	32
2-6	3	48
	Total N/A =	80 lbs

The N fertilizer requirement of semi-dwarf and hard red winter and club wheats can be estimated using the following tables and the N soil test values.

TABLE 1: Use this table when soil samples are taken during the spring of the summer fallow year.

Estimated Yield bu/A	TO OBTAIN N FERTILIZER RATE subtract N soil test value (lbs/A) from the appropriate number	
	Semidwarf	Hard Red and Club
100	195	
95	185	
90	170	
85	160	
80	145	210
75	135	195
70	125	180
65	110	165
60	100	145
55	85	130
50	75	115
45	65	100
40	50	85
35	40	65
30	25	50
25	15	35
20	0	20

TABLE 2: Use this table when soil samples are taken during the spring of the cropping year.

100	170	
95	160	
90	150	
85	140	
80	130	185
75	120	170
70	110	160
65	100	145
60	90	130
55	80	120
50	70	105
45	60	90
40	50	80
35	40	65
30	30	50
25	20	35
20	10	25

Note: When soil samples are taken in the fall of the summer fallow year add 15 lbs. N/A to the fertilizer rates calculated from Table 1.

Sample calculations:

Case 1: Hard red wheat
Estimated yield = 60 bu/A
Soil sampled spring of summer fallow yr.
Soil depth = 5'
Soil test values
0-2' = 4 ppm N = 32 # N/A
2-5' = 5 ppm N = 60 # N/A
Total = 92 # N/A
Suggest rate of N fertilizer = 145 - 92 = 53 # N/A

Case 2: Semi dwarf wheat
Estimated yield = 80 bu/A
Soil sampled spring of cropping year
Soil depth = 7'
Soil test values
0-2' = 6 ppm N = 48 # N/A
2-6' = 4 ppm N = 64 # N/A
Total = 112 # N/A
Suggested rate of N fertilizer = 130-112 = 18 # N/A

Case 3: Club wheat
Estimated yield = 40 bu/A
Soil sampled fall of summer fallow year
Soil test value = 36 # N/A
Suggest rate of N fertilizer = 85-36 = 49+15 = 64 # N/A

If the soil test value for N is less than 3 ppm in the 0-2 ft. depth, then a minimum of 20 lbs N/A should be applied regardless of the soil test value for N below 2 ft. This also applies when soil samples are taken during the spring of the cropping year where wheat has poor growth or is not well tillered. Spring application of N will usually promote early growth in the spring under these conditions.

Soil samples are usually tested for nitrate -N (NO_3-N) but in cases where significant amounts of ammonium -N (NH_4-N) might be present (such as described below for spring samples) the soil test value for N, for the 0-2 ft. soil depth should include both NO_3-N and NH_4-N.

When soil samples are removed in the spring of the cropping year following a fall application of N fertilizer which contained ammonia or ammonium, the surface sample (0-2') should be tested for NH_4-N and NO_3-N and the sum of these two values should be used as the soil test value for the surface 2 feet of soil.

Estimated Yield

The grower will usually base his estimate of yield on soil moisture conditions at the time of sampling and his experience of wheat yields in the field being sampled.

If the yield estimate is made prior to fertilization during the summer fallow year, then soil moisture trends until crop harvest of the following year cannot be accurately predicted. Should soil moisture prove to be better than predicted, additional fertilizer can be applied during the fall to early spring period.

SULFUR (S)

The application of S fertilizer is suggested when the estimated yield exceeds 30 bu/A and the average soil test for sulfate in the surface 2' of soil is less than 2 ppm.

The suggested rate of S application is 10 lbs S/A for each crop. An application of 15-20 lbs S/A should suffice for 2 crops. High yielding crops require more S than low yielding crops.

PHOSPHORUS (P)

The estimated P fertilizer requirement is based on testing the surface foot of soil.

If the OSU Soil Test* for P reads (ppm):	Apply this amount of phosphurus (lbs/A)
0-8	13-22 (30-50 lbs P_2O_5)
8-10	0-13 (0-30 lbs P_2O_5)
over 10	0

*These soil test values are based on a 0-1 foot sampling depth. When the soil sample is from the 0-2 ft. depth substitute 4 and 6 ppm for 8 and 10 ppm OSU soil test values.

P fertilizer is most effective if banded 1-2" to the side or below seed.

OTHER FERTILIZERS

Grain yield responses to other nutrients such as potassium, calcium, magnesium, boron, and zinc have not been measured in Columbia plateau wheat fields.

Suggested applications of N, S, and P based on soil test values from OSU Soil Testing Laboratory.

Suggested fertilizer applications based on field trials conducted by Thomas W. Thompson, Harold Kerr, Martin Zimmerman, John Hesketh, Fred Hagelstein, Gordon Cook, and Hugh Gardner; OSU Extension Service and Warren Kronstad and Jack McDermid; OSU Agricultural Experiment Station.

Prepared by Hugh Gardner, Soil Scientist, and N.R. Goetze, Agronomist, OSU Extension Service, and reviewed by OSU County Extension Agents for the Columbia Plateau region and by Paul E. Rasmussen, ARS-USDA, Columbia Plateau Conservation and Research Center.

OREGON STATE UNIVERSITY EXTENSION SERVICE

Oregon State University Fertilizer Guide for

Extension Service, Oregon State University, Henry A. Wadsworth, director. This publication was produced and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. Extension work is a cooperative program of Oregon State University, the U.S. Department of Agriculture, and Oregon counties. Extension invites participation in its programs and offers them equally to all people.

FG 40
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IRRIGATED SEMI-DWARF WHEAT

(Eastern Oregon - East of Cascades)

Good management practices are essential if optimum fertilizer responses are to be realized. These practices include adequate irrigation, use of recommended varieties, selection of adapted soils, weed control, disease and insect control, good seed bed preparation, proper seeding methods, and timely harvest.

It is important that the soil be sampled and tested as a guide to fertilization. Follow recommended soil sampling procedures, available from your County Agent, to insure satisfactory fertilizer recommendation.

NITROGEN (N)

Irrigated grain requires a good supply of available N; however, excessive rates of N can reduce grain quality and increase the risk of lodging. An optimum response to N fertilization depends on adequate irrigation. The N applications suggested in this guide are based on the maintenance of good soil moisture throughout the growing season.

Of the suggested N application 25 to 50% of the N should be applied preplant or at planting and 25 to 50% should be applied in early spring. The remainder of the N can be applied during the growing season. The urea or diammonium phosphate forms of N may cause seedling injury if banded close to the seed at planting.

The amount of N fertilizer required depends on the following factors: the preceding crop; the N carry-over from the previous crop; the amount and type of residue to be plowed under; and possible leaching losses due to over-irrigation.

The following fertilizer guides are for mineral soils with low organic matter content unless otherwise stated.

N Fertilizer Guide Based On Soil Test

The amount of residual N in the soil varies considerably.

A soil test for nitrate-N (NO_3-N) helps in evaluating the N carry-over from the previous crops in the case of mineral soils with low organic matter content.

N soil tests are not recommended following alfalfa (or other legumes) or for muck and peat soils.

Soil samples for NO_3-N should be taken following a growing season and prior to the application of N fertilizer.

Soil samples should be taken from the 0-2' (0-0.6 m) and 2-6' (0.6-1.8 m) soil depths on deep soils. The soil samples should consist of soil cores removed from the entire 0-2' and 2-6' depth of soil. On soils shallower than 6', soil samples should be taken from 0-2' and from 2' to the rooting depth.

OSU soil test results for N are reported in ppm. One ppm N in a 1' depth of soil equals about 4 lbs N/acre.

As an example:

Soil Depth		Soil Test NO_3-N		
(ft)	(m)	ppm	lbs/A	kg/ha
0-2	0-0.6	4	32	36
2-6	0.6-1.8	3	48	54
		Total	80 lbs (90 kg)	NO_3-N

The total NO_3-N soil test values are used to estimate the N fertilizer requirement as indicated in the following table:

NO_3-N Soil Test		N Application[1/]	
(lbs/A)	kg/ha	(lbs/A)	kg/ha
0- 40	0-45	120-160	135-180
40- 80	45-90	80-120	90-135
80-120	90-135	40- 80	45- 90
120-160	135-180	0-40	0-45
160-200	180-225	0	0

[1/] These application rates are suggested for silt loam, loam, and clay loam soils. For sandy soils the application rates should be increased by 25%.

Should the soil test value for NO_3-N be less than 2 ppm in the 0-2' soil depth apply a minimum of 30 lbs/A (35 kg/ha) N when well-tillered wheat plants are not present regardless of the soil test value for N below 2'. This application is to insure adequate initial growth of wheat plants.

N Fertilizer Guide Based On Previous Crop

Where a soil test is not used, N fertilization would be based on the preceding crop.

As the amount of residual N in the soil varies considerably, a soil test is usually the most accurate method of estimating N fertilizer needs except following a legume crop.

Previous Crop	N Application[1/] lbs/A	kg/ha
Grass Sod	140-160	155-180
Grain	120-140	135-155
Potatoes and Peppermint	80-100	90-110
Productive Alfalfa	60-80	65-90

[1/] It may be necessary to increase these rates by about 25% to optimize yields on sandy soils.

PHOSPHORUS (P)

Best results are obtained when P is banded at planting time. Plowing P down before planting is preferable to broadcast applications.

For mineral soils:

If OSU soil test for P reads (ppm)	Apply this amount of Phosphorus (P_2O_5)[1/] Central OR. and Klamath Co. lbs/A	kg/ha	Remainder of Eastern OR. lbs/A	kg/ha
0-10	80	90	60	65
10-20	40	45	0	0
Over 20	0	0	0	0

[1/] The application rate should be increased by 50% if P is not banded.

On muck soils in the Klamath area apply 40 lbs P_2O_5/A.

POTASSIUM (K)

K fertilizers usually are not required for production of irrigated spring planted small grain in eastern Oregon, but *K responses may be obtained when OSU soil test values for mineral soils for K are less than 100 ppm.* In this case 30 to 50 lbs K_2O/A should be banded at least 2 inches from the seed at planting time or plowed down prior to planting.

On the acid muck soils in Klamath County, small grains have responded to the application of K.

SULFUR (S)

S requirements will vary with soil texture, leaching losses, and the soil parent material. *S is frequently contained in fertilizers* used to supply other nutrients such as N, P, and K and may be present in irrigation water which can be tested for S content.

Plants absorb S in the form of sulfate. Fertilizer materials supply S in the form of sulfate and elemental S. *Elemental S must convert to sulfate in the soil before the S becomes available to plants.* The conversion of elemental S to sulfate is usually rapid for fine ground (less than 40 mesh) material in warm, moist soil. *Elemental S should be applied the year preceding* the grain crop using finely ground (less than 40 mesh) material.

Elemental S is a strong soil acidifier.

S in the sulfate form can be applied at planting time.

If OSU soil test for SO_4-S in the 0-2' soil depth reads (ppm)	Apply this amount of S[1/] Loamy Soil (lbs/A)	Sandy Soil (lbs/A)
0-2	0-20	40-60
2-5	0	20-40
5-8	0	0-20
Over 8	0	0

[1/] When the irrigation water contains over 2 ppm of S, additional S fertilizer is probably not required.

MAGNESIUM

Responses of small grains to applications of magnesium have not been observed on mineral soils in eastern Oregon.

LIME

Responses of wheat to lime have not been observed in eastern Oregon; however, where the soil test pH value is less than 5.5 a lime application is suggested.

On sandy soils where soil acidity is most prevalent, one ton of dry 100-score lime raises the pH about 1 unit. In most instances 1 to 1½ tons lime/A is adequate to correct soil acidity.

Lime should be mixed into the seedbed at least several weeks before seeding. A lime application is effective over several years.

MICRONUTRIENT ELEMENTS

In the Klamath area, a micronutrient mix containing zinc, copper, and manganese has given yield responses with small grains on muck soils.

MANURE

Manure can be used as a source of nutrients for small grains. Information on the use of manure is available from your county agent.

CONVERSION TO METRIC UNITS

In this FG, English and metric units are used. The abbreviations and Conversion Factors (C.F.) are:

From	To	C.F.
Feet (')	Meters (m)	0.305
Inches (")	Centimeters (cm)	2.54
Pounds (lb)	Kilograms (kg)	0.454
Acres (A)	Hectares (ha)	0.405
Tons (T)	Metric tons (Tm)	0.907
Pounds per Acre (lb/A)	Kilograms per Hectare (kg/ha)	1.12
Tons per Acre (T/A)	Metric Tons per Hectare (Tm/ha)	2.24

N, P, K, S, and lime suggested are based on soil test values from the Soil Testing Laboratory, OSU, Corvallis, Oregon.

Guide to fertilization based on experiments conducted by Malcolm Johnson, Vance Pumphrey, and T. L. Jackson, Oregon Agricultural Experiment Station; Bert G. Wilcox, OSU Extension Service; and observation of growers' results.

Prepared by E. Hugh Gardner, Norm Goetze, Bert G. Wilcox, Oris Rudd, and Luther Fitch, Extension Service; and T. L. Jackson, Malcolm Johnson, and Vance Pumphrey, Agricultural Experiment Station, Oregon State University, Corvallis. Reviewed by a committee of eastern Oregon county agents.

COOPERATIVE EXTENSION SERVICE
OREGON STATE UNIVERSITY
Oregon State University Fertilizer Guide for

FG 37
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Irrigated Spring-Planted Small Grains

(Eastern Oregon-East of Cascades)

Good management practices are essential if optimum fertilizer response are to be realized. These practices include adequate irrigation use of recommended varieties, selection of adapted soils, weed control, disease and insect control, good seed bed preparation, proper seeding methods, and timely harvest.

It is important that the soil be sampled and tested as a guide to fertilization. Follow recommended soil sampling procedures to insure satisfactory fertilizer recommendation. Your County Agent can provide you with instructions on correct soil sampling.

NITROGEN (N)

Irrigated grain requires a good supply of available N, however, excessive rates of N can reduce grain quality and increase the risk of lodging. An optimum response to N fertilization depends on adequate irrigation. The N applications suggested in this guide are based on the maintenance of good soil moisture throughout the growing season.

Of the suggested N application at least ¼ of the N should be applied before or at planting time. The urea or diammonium phosphate forms of N may cause seedling injury if banded close to the seed at planting. The remainder of the N should be plowed down, injected, or applied through the sprinkler system.

The amount of N fertilizer required depends on the following factors: the preceding crop; the N carry-over from the previous crop; the amount and type of residue to be plowed under; and possible leaching losses due to over-irrigation.

The following fertilizer guides are for mineral soils.

N Fertilizer Guide Based On Soil Test

The amount of residual N in the soil varies considerably.

A soil test for nitrate-N (NO_3-N) helps in evaluating the N carryover from the previous crops in the case of mineral soils with low organic matter content.
Nitrogen soil tests are not recommended for alfalfa (or other legumes).
Soil samples for NO_3-N should be taken following a growing season and prior to the application of N fertilizer.

Soil samples should be taken from the 0-2' and 2-6' soil depths on deep soils. The soil samples should consist of soil cores removed from the entire 0-2 feet and 2-6 feet depth of soil. On soils shallower than 6', soil samples should be taken from 0-2' and from 2' to the rooting depth.

It is important to follow correct soil sampling procedures as outlined in OSU Extension Circular 628. This publication is available from county extension offices.

OSU soil test results for N are reported in ppm. One ppm N in a 1 foot depth of soil equals about 4 lbs N/acre.

As an example:

Soil Depth (ft)	Soil Test ppm	NO_3-N lbs/A
0-2	4	32
2-6	3	48
	Total	80 lbs NO_3-N

The total NO_3-N soil test values are used to estimate the N fertilizer requirement as indicated in the following table:

NO_3-N Soil Test (lbs/A)	N Application (lbs/A)[1/]	
	Wheat	Oats and Barley
0-40	120-160	60-100
40-80	80-120	20-60
80-120	40-80	0-20
120-160	0-40	0
160-200	0	0

[1/] These application rates are suggested for silt loam, loam, and clay loam soils. For sandy soils the application rates should be increased by ¼.

Should the soil test value for NO_3-N be less than 2 ppm in the 0-2 ft soil depth then a minimum of 30 lbs/N/A should be applied when well-tillered wheat plants are not present regardless of the soil test value for N below 2 ft. This application is to insure adequate initial growth of wheat plants.

N Fertilizer Guide Based On Previous Crop

Where a soil test is not used, N fertilization

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would be based on the preceding crop.

As the amount of residual N in the soil varies considerably, a soil test is usually the most accurate method of estimating N fertilizer needs except following a legume crop.

Previous Crop	N Application (lbs/A)[1]	
	Wheat	Oats and Barley
Grass Sod	140-160	80-100
Grain	120-140	60- 80
Potatoes and Peppermint	80-100	40-60
Productive Alfalfa	60-80	20-40

[1] It may be necessary to increase these rates by about ¼ to optimize yields on sandy soils.

PHOSPHORUS (P)

Best results are obtained when P is banded at planting time. Plowing P down before planting is preferable to broadcast applications.

For mineral soils:

If OSU soil test for P reads (ppm)	Apply this amount of phosphorus (P_2O_5)-lbs/A[1]	
	Central OR. and Klamath Ct.	Remainder of Eastern OR.
0-10	80	60
10-20	40	0
over 20	0	0

[1] The application rate should be increased by 50% if P is not banded. On muck soils in the Klamath area apply 40 lbs P_2O_5/A.

POTASSIUM (K)

K fertilizers usually are not required for production of irrigated spring planted small grain in Eastern Oregon, but *potassium responses may be obtained when OSU soil test values for mineral soils for K are less than 100 ppm.* In this case 30 to 50 lbs K_2O/A should be banded at planting time or plowed down prior to planting.

On the muck acid soils in Klamath County, small grains have responded to the application of potassium.

SULFUR (S)

S requirements will vary with soil texture, leaching losses, and the soil parent material. *S is frequently contained in fertilizers* used to supply other nutrients such as N, P, and K and may be present in irrigation water which can be tested for S content.

Plants absorb S in the form of sulfate. Fertilizer materials supply S in the form of sulfate and elemental S. *Elemental S must convert to sulfate in the soil before the S becomes available to plants.* The conversion of elemental S to sulfate is usually rapid for fine ground (less than 40 mesh) material in warm, moist soil. *Elemental S should be used only on soils with a pH of 7 or higher and applied the year preceding* the grain crop using fine ground (less than 40 mesh) material.

S in the sulfate form can be applied at planting time.

If OSU soil test for SO_4-S in the 0-2' soil depth reads (ppm)	Apply this amount of S[1] (lbs/A)	
	Loamy Soil	Sandy Soil
0-2	0-20	40-60
2-5	0	20-40
5-8	0	0-20
over 8	0	0

[1] When the irrigation water contains over 2 ppm of S, additional S fertilizer is probably not required.

MAGNESIUM AND LIME

Responses of small grains to applications of magnesium and lime have not been obtained on mineral soils in eastern Oregon.

MICRONUTRIENT ELEMENTS

In the Klamath area, a micronutrient mix containing zinc, copper, and manganese has given yield responses with small grains on muck soils.

MANURE

Manure can be used as a source of nutrients for small grains. Information on the use of manure is available from your county agent.

N, P, K, and S suggestions are based on soil test values from the Soil Testing Laboratory, OSU, Corvallis, Oregon.

Guide to fertilization based on experiments conducted by Malcolom Johnson, Vance Pumphrey, and T. L. Jackson, Oregon Agricultural Experiment Station; Bert G. Wilcox, OSU Extension Service; and observation of growers' results.

Prepared by E. Hugh Gardner, Bert G. Wilcox, Oris Rudd, and Luther Fitch, Extension Service; and T. L. Jackson, Malcolm Johnson, and Vance Pumphrey, Agricultural Experiment Station, Oregon State University, Corvallis. Reviewed by a committee of Eastern Oregon County Agents.

Preparing the land

The time and method of preparing the land for wheat depends principally on the crop that precedes it. Unless rainfall is high and the land subject to erosion, it is desirable to have the land prepared considerably in advance of seeding to permit settling and the accumulation of moisture and available plant food, especially nitrates. The soil can generally be plowed easily when it is in a proper friable condition. After the ground dries, it is likely to turn up cloddy and will be difficult to work into a good seedbed.

The depth of plowing should be governed to a considerable extent by the quantity of stubble, weeds, and cover crop to be turned under, and it should be deep enough to do this thoroughly. With the cost of fuel increasing so rapidly there is more interest in minimum or no-tillage techniques. Basically the stubble is left untouched or "Heavy Disked" and the next crop is drilled with little soil preparation.

Usually, the time of harvesting and the condition of the land after the crop is removed determine the preparation of the ground for wheat.

Seed and seedling

Wheat is normally self-pollinated; therefore, pure seed of an adapted variety will not change because of the locality in which it is grown provided there is no mixture with other varieties. It is advisable to go to a source of certified seed to avoid mixtures, weeds, or seedbone diseases that would contaminate the variety.

Sound wheat that has been stored in a dry bin ordinarily germinates satisfactorily. However, if it has been wet or there is any other reason to suspect that its vitality has been impaired, it should not be sown, unless it germinates at least 90 percent. Germination can be determined by a simple test. Viable seed placed on moist blotting paper, enclosed in a glass container with a loose-fitting cover or loosely in a plastic bag, will germinate in 3 to 5 days if maintained at room temperature (70^{o} F.) and exposed to nomal light (not in direct sunlight). Some varieties have a short (4 to 12 weeks) period of dormacy after ripening. During this time an erratic germination response may be observed. A later test, after chilling soaked seed at 40^{o} F. for 5 days, may show the seed to be entirely satisfactory. Wheat 1,2, or even 3 years old may be used for seed if it germinates satisfactorily. Seed older than this is likely to be unsatisfactory.

In the early history of this country, wheat was sown broadcast for lack of satisfactory machinery, but today wheat is sown with a drill.

Drilling saves seed, insures better germination and more uniform stands, reduces winter injury, and almost always produces better yields. Drills are of three general types -- hoe, shoe, and single and double disks. Single-disk drills are used most commonly. Hoe drills are satisfactory only on clean land. They, also have some advantages on stony land. Drill 1 1/2" - 2" deep in Western Oregon and in irrigated Eastern or Central Oregon at a row spacing of 7" and 110 lbs./acre. Dry land wheat is usually drilled 2 -5" deep. A furrow up to 3" deep is used and the seed is put 2" be-

neath the soil level in the bottom of the furrow thus a seed is 5" from the surface of the field but 2" from the surface of the bottom of the furrow. Rows are 12, 14, or 16" apart with drilling rates of about 30 lbs./acre. If the land is subject to washing, the drilling should be on the contour to reduce erosion.

Time of seeding

Wheat should be sown early enough to become well established before winter, but not so early that it makes a rank growth or starts to shoot before winter. Therefore, time of seeding will depend on your location within the state of Oregon. Northeastern Oregon, Southern Oregon, and the Willamette Valley all have differing times of seeding. The time of seeding within a given location will change with major changes in weather during a given year. For example, in the Willamette Valley wheat is generally drilled in late October. However, during a dry year there are advantages to waiting until November.

Weeds and Their Control

The following weeds are major weed problems for wheat production on the east and west sides of the Cascade Mountains.

East side:

1. Cheatgrass
2. Purple Mustard
3. Wild Oats (high rainfall areas)

West side:

1. Annual Ryegrass
2. Wild Oats
3. Miscellaneous Broadleafed Weeds
   (Mustard, Radish, Canada Thistle, etc.)

For accurate information regarding chemical control of these and other weed problems in your local area refer to the Oregon Weed Control Handbook. It will have the most current information on chemical control for various weed problems.

Harvesting

Essentially all wheat is harvested with the combine. Harvesting can be done rapidly when the weather is dry. Grain cannot be stored safetly until the moisture content is below 14 percent. Artificial drying of wet wheat can hasten the harvest date when appropriate equipment is available. If moisture content is too high, the kernels may be damaged. Spoilage in the bin almost inevitably results when damp or slightly immature grain is put into a tight bin in large quantities.

As wheat approaches maturity, the kernel loses moisture rapidly, and after it has ripened (stopped growing) it dries out even more rapidly. Eight to ten days before ripening the kernels may contain up to 50 percent moisture. The kernels are fully developed when the moisture content has fallen below about 35 percent but wheat cannot be combined for several days. To test for degree of dryness of a wheat head, rotate or rub the head between the palms of your hands. If the kernels shell out and a majority of central stems of the heads break, then the moisture content is about right for combining. If the kernels do not shell out readily, the wheat will be too damp for combining. When the separated grain feels damp or is easily dented with the thumbnail, it is too wet to combine. When a moisture meter is available at a nearby Extension Office or Elevator, accurate moisture determinations can be made.

A combine is subjected to strain when operating in a crop heavily infested with green weeds, for high-moisture content makes them comparatively heavy. Chopped-up green weeds are difficult to separate from the threshed grain, and the excess moisture in them is absorbed by the grain within 24 hours. Operating the cutter bar above the level of the weeds helps some, but grain can be lost in this procedure. Generally, a weedy field is best harvested with a windrower and later combined after the grain and weeds have dried. For best results in windrowing, the windrow should be supported

and held above the ground by the stubble to prevent wet weather from damaging the crop. After sufficient drying, use the combine with a pickup attachment driven along the windrow in the same direction as that in which the crop was cut. When this is done, the straw is more likely to be fed headfirst into the cylinder. Another alternative is to kill the weeds several days before harvest with a chemical herbicide.

Characteristics desirable in wheat for combine harvesting are strong straw, uniform ripening. nonshattering seed habit, and erect heads of uniform height.

In some areas wheat straw is a valuable part of the crop. The combine scatters the straw over the field, but it can be gathered during combining with a straw buncher, or after harvest with a pickup baler.

Storing the grain

The most important factors in storage of wheat are the moisture content of the grain and temperature. The drier the grain and the lower the temperature, the better the wheat will keep. Atmospheric humidity is of minor importance. Dry grain will take up moisture if exposed to damp air, but only the grain at the surface of a bin is exposed. Insects, rodents, and birds should be excluded.

Removing weed seeds, broken kernels, chaff, and other foreign materials improve the keeping quality of wheat. If the grain contains many green weed seeds or broken bits of green stems, remove them immediately to prevent absorption of moisture by the wheat.

If artificial drying is used to get the moisture content of the threshed wheat down to 14 percent or less, control the temperature carefully. The upper limit is about 110° degrees F. if the grain is to be used for seed. A maximum of 140° degrees F. can be used if the wheat is to be milled or fed.

A number of insects attack wheat in storage. Insects can be controlled by having the grain clean and low in moisture content before storing, by cleaning and spraying empty bins with insecticide, by general sanitation in and near the bin, and by fumigation.

3. WHAT INSECTS AND DISEASES ATTACK GROWING WHEAT?

Insect Problems

The major insect problems for wheat producers in Oregon are:

1. Green bug (green aphid)
2. Peach Leaf Cherrybird aphid
3. Hessian fly (minor importance in some areas)

Consult the Oregon Disease Control Handbook for the most recent chemical control of the identified insect pests. Local extension agents have copies of the books or they can be purchased through the Oregon State University Bookstore.

The Oregon Weed Control Handbook, Disease Control Handbook, and Insect Control Handbook are all updated each year to keep up with the changes in chemical registration, be sure to use the current years copy.

Disease Problems

The major disease problems for wheat producers in Oregon are as follows:

East side of Cascades:

1. Stripe Rust
2. Cerecosporolla (Straw breaker)
3. Snow mold

West side of Cascades:

1. Septoria
2. Take-all Root Rot
3. Smut

For the most accurate information regarding control of these diseases consult the Oregon Disease Control Handbook.

Following are Enterprise Data sheets which will identify production practices and cost of production.

These are available at the OSU Extension Office in your county.

OREGON STATE UNIVERSITY EXTENSION SERVICE

WINTER WHEAT
Mid-Willamette Valley

Based on:

1. 100 Ac. on 500 Ac. farm
2. 75 bushel yield per acre
3. 90 h.p. tractor @ $11.60/hr.
4. 120 h.p. tractor @ $14.60/hr.
5. Hired labor @ $5.15/hr. 1/
6. Operators labor @ $6.85/hr.

	Labor		Machinery	Other		Total cost
	Hrs.	Value ($)	($)	Item	Value ($)	($)
Cultural Operations 2/						
Plow	.33	2.25	7.45			9.70
Cultimulch (1.5X)	.15	1.05	3.45			4.50
Drill & harrow	.25	1.70	6.15	Seed	9.80	
				Fert.	14.85	32.50
Herbicide (fall) 3/				Custom	9.15	9.15
Herbicide (winter) 3/				Custom	13.50	13.50
Insect & rodent control					.55	.55
Fertilizer (spring)				Custom	40.00	40.00
Herbicide (spring)					4.80	4.80
Lime 4/					8.15	8.15
Harvest						
Combining	.7	4.80	35.75			40.55
Hauling	.7	3.60	4.50			8.10
Other Charges						
Land charge 5/					80.00	80.00
Operating capital interest (16.5%)					8.95	8.95
General overhead 6/					12.50	12.50
Management charge 7/					13.65	13.65
Cash Cost		3.60	25.80		122.25	151.65
Non-Cash Cost		9.80	31.50		93.65	134.95
Total Cost		13.40	57.30		215.90	286.60
Cost per bu. @ 55 bu. yield						5.10
Cost per bu. @ 75 bu. yield						3.80
Cost per bu. @ 95 bu. yield						3.10

1/ Includes SAIF and other payroll expenses.
2/ Consult your extension agent for specific recommendations on cultural practices.
3/ One spray for ryegrass control and winter spray for wild oat control.
4/ Cost amortized over 8 year life.
5/ Land charge is based on rental but is considered a non-cash cost.
6/ Approximately 9% of cash costs.
7/ Approximately 9% of cash costs.

These data were obtained and computed by John Burt, Polk County Extension Agent, in cooperation with Mid-Willamette Valley Producers.

Department of Agricultural and Resource Economics, May 1981.

OREGON STATE UNIVERSITY
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DRYLAND WHEAT
Morrow County

Based on:

1. 1,250 acres harvested, 1,250 acres fallow
2. Average yield of 27 bu./acre
3. Labor cost: Operator @ $7.50/hr.
   Hired @ $7.50/hr. 1/
4. 105 H.P. crawler @ $24.85
5. 20' Hillside Combine @ $102.32/hr.

INPUTS PER HARVESTED ACRE

	Labor		Machinery		Other		Total	Your
	Hrs.	Value ($)	Operating ($)	Ownership ($)	Item	Value ($)	cost ($)	cost ($)
Cultural Operations								
Chisel plow 32' (2X)	.22	1.65	3.15	7.05			11.85	
Cultivator 42'	.06	.45	.75	1.75			2.95	
Rod weeding 48' (4X)	.16	1.20	2.25	3.75			7.20	
Fertilize 60' 2/	.04	.30	.40	.60	25#N	5.00	6.30	
Seeding 32' (1.1X) 3/	.07	.55	.95	2.75	60#	6.70	10.95	
Haul seed	.008	.05	.15	.35			.55	
Weed spray					Chemical	4.35		
					Appl.	2.50	6.85	
Harvest								
Combine 20'	.14	1.05	4.80	9.55			15.40	
Haul grain	.20	1.50	1.50	3.70			6.70	
Other Charges								
Other labor (operator's)	.58	4.35					4.35	
Pickup truck 4/			1.75	1.75			3.50	
Other machinery			.85	3.60			4.45	
Conservation practices						.75	.75	
Crop insurance 5/						3.00	3.00	
Marketing 6/						10.00	10.00	
Operating capital interest (13%)						3.15	3.15	
Interest on land (2 A. @ $250 @ 12%)						60.00	60.00	
Taxes on land						3.35	3.35	
Management charge						5.00	5.00	
Miscellaneous						4.00	4.00	
Cash Costs		1.50	16.55	.95		42.80	61.80	
Non-Cash Costs		9.60	0	33.90		65.00	108.50	
TOTAL COST		11.10	16.55	34.85		107.80	170.30	
Cost per bushel @ 22 bu. yield							7.66	
Cost per bushel @ 27 bu. yield							6.31	
Cost per bushel @ 32 bu. yield							5.38	

----(Footnotes on back)----

These data were developed by County Agent Harold Ker and Extension Economics Assistant David Holst in cooperation with Morrow County growers.

Department of Agricultural & Resource Economics, November 1980.

1/ Includes wages, social security, workmen's compensation, and benefits.

2/ Fertilizer applicator furnished by company.

3/ There are two sets of drills and 10% of acreage reseeded.

4/ Pickup truck driven 10,000 miles per year.

5/ Crop insurance includes fire, hail, and Federal Crop Insurance.

6/ Marketing costs include elevator put-through @ 10¢/bu., storage @ 6¢/bu. for 120 days, transportation to Portland @ 20¢/bu., and wheat tax @ 1¢/bu.

OREGON STATE UNIVERSITY EXTENSION SERVICE

IRRIGATED WHEAT
Hermiston Area

Based on:

1. 125 acres on 500 acre farm[1/]
2. Planted in rotation following row crop.
3. Normal yield of 70 bushels per acre.
4. Machinery labor @ $4.50 per hour.
5. Other labor @ $3.50 per hour.
6. Side-roll irrigation system.

UNITS PER ACRE

	Labor		Machinery & Equipment		Other		Total
	Hrs.	Value	Operating[2/]	Ownership[3/]	Item	Value	cost
		($)	($)	($)		($)	($)
Cultural Operations[4/]							
Disc and pack	.20	.90	1.54	2.47			4.91
Fertilize	.10	.45	.16	.29	Mtls.	64.60	
					Sprdr. rent	.75	66.25
Drill	.30	1.35	1.91	3.84	Seed	10.00	17.10
Spray					Mtls.	4.00	
					Custom	2.50	6.50
Irrigate	3.71	12.99	3.28	27.55	Water dist.	11.00	
					Power	9.24	64.06
Harvesting							
Harvest (25¢/bu.)					Custom	17.50	17.50
Haul (8¢/bu.)					Custom	5.60	5.60
Post-Harvest							
Stubble beaters	.25	1.13	1.47	2.42			5.02
Disc and pack	.20	.90	1.54	2.47			4.91
Other Charges							
Misc. labor	.50	1.75					1.75
Fire and hail insurance						7.00	7.00
Operating capital int. 5/						6.96	6.96
Land taxes 6/						10.00	10.00
Interest on land ($1,000 @ 9%)						90.00	90.00
Management 7/						12.30	12.30
Overhead 8/						9.23	9.23
TOTAL COST PER ACRE		19.47	9.90	39.04		260.68	329.09
Cost per bushel @ 60 bushel yield							5.42
Cost per bushel @ 70 bushel yield							4.70
Cost per bushel @ 90 bushel yield							3.74

1/This is a diversified irrigated farm. As such, operations and costs may differ from what would be expected on a specialized wheat farm.
2/Includes fuel, lubrication, and repairs.
3/Includes depreciation, interest on average investment, property taxes, and insurance.
4/Assumes (1)130 hp. four wheel drive tractor @ $11.83 per hr. & (2)100 hp. tractor @ $9.46 per hr.
5/Assumes that the cash expenses are outstanding for half a year with a 9% annual int. charge.
6/Based on farm use value.
7/Estimated at 4% of all costs except overhead.
8/Estimated at 3% of all costs except management.

These data were obtained and computed by Extension Assistant David Holst with the assistance of County Agent Luther Fitch and Hermiston area wheat growers.

Department of Agricultural and Resource Economics, December 1977.

For additional information about wheat production in Oregon the following OSU Extension materials are provided in this unit:

1. Growing Winter Wheat on Poorly Drained Soil
2. Combating Take-All Root Rot of Winter Wheat in Western Oregon
3. Herbicides for Annual Weed Control in Wheat in Eastern Oregon

Wheat producers in the Columbia Plateau area should follow the wheat production practices outlined in the "Annual Report" for the Oregon State University Experiment Station at Pendleton Oregon, for wheat production.

FS 269
July 1981

Growing Winter Wheat on Poorly Drained Soil

Theory

Poorly drained soils have low oxygen levels because the air spaces are filled with water throughout the rainy season. Oxygen is required for normal root growth, so root development is restricted when the soils remain flooded. In the absence of oxygen, soil manganese is converted to a particular chemical form, which in large quantities is toxic to wheat seedlings. Seedlings growing on low ridges of poorly drained soil have a better chance to develop normal crown root systems because oxygen supplies are more adequate during the winter months.

In many countries, annual crops grown in areas with heavy rainfall are planted in raised beds or on ridges. Decades ago Willamette Valley farmers plowed their flat, poorly drained fields in "lands" or strips in the same direction each year. These "lands" left permanent parallel ditches 40 to 60 feet apart to drain surface water away from the seedling roots. In areas of the Sacramento Valley where winter drainage is a problem, farmers plant wheat on beds 4 to 5 feet wide on flat fields.

Experimental results

Early experiments in growing winter wheat on poorly drained soils in western Oregon were conducted on the drainage research farm near Lebanon from 1960 through 1964. Bedding disks attached to a diamond tool bar were used to shape beds about 10 feet wide. Use of these 10-foot beds increased wheat yields by 20 to 40 bushels per acre. This required another tillage operation, however, to level the field for the next crop.

Since 1976, 6-inch ditching shovels on 20- to 30-inch spacings have been used to remove water from around the crown of plants. These ditches "melt" down by summer so that normal fall tillage can be used on the following crop. On soils with medium to fair drainage, yields have increased from 8 to 16 bushels per acre over the yield on non-ridged treatments. On the poorly drained soils, where no crop could be produced without ridging, yields have ranged from 30 to 60 bushels per acre.

Current farm experiences

Seven growers in the southern Willamette Valley successfully produced 600 acres of winter wheat on ridges or beds in 1980. Their yields ranged from 48 to 65 bushels per acre on soil that normally could not be used for winter wheat. These yields were comparable to conventionally planted wheat on well-drained soils in that area.

Their planting equipment was modified in a variety of ways. A shovel 6 to 8 inches wide was mounted directly on the drill in front of every third or fourth drill opener or on a tool bar that was pulled ahead of the drill. The point of the shovel was about 2 inches below the bottom of the opening of the drill. The shovel throws dirt out of the furrow, creating a ridge or raised bed into which the drill plants. Shovels can be spaced up to 42 inches apart if enough speed can be maintained. In this case a ground speed of 8½ miles per hour was required. The size and shape of the bed or ridges varies with size of shovel, depth of operation, distance between shovel and drill opener, and tractor speed. One grower used an onion bedder, which made beds 6 inches to 8 inches high. These bedders also worked well in areas where ditching and drainage from the field was a problem. This equipment was considerably higher in cost than the three-point tool bar with four or five shovels, however. In theory a bed of any height will work as long as the water can run off into the furrow. In practice it appears 3 inches from the bottom of the furrow to the top of the crown on the bed should be the minimum. No matter how high the bed, the wheat will die if the water in the field goes over the top of the bed for any length of time. Drainage of water is, therefore, very important.

The normal herbicide and fertilizer applications were made with conventional equipment. Combines could pass over the ridges successfully, but trucks and pickups had difficulty. All seven growers were planning to expand their acreages of wheat planted on beds or ridges in the fall of 1980.

Current recommendations

Prepare a conventional seedbed while the soil is still dry. Avoid excess pulverization. Much of the poorly drained soil is acidic. Application of lime to raise the pH to 5.6 or more is beneficial. There is a significant advantage when 150 pounds of 16-20-0 fertilizer per acre is banded with the seed.

Use 100 to 120 pounds of seed per acre. You can save seed by plugging the drill rows in areas immediately above the furrows. Use the normal calibration to adjust

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the seeding rate. Yamhill is the best variety of wheat for the most poorly drained soil. Stephens will yield equally well on the marginally drained soils if satisfactory beds or ridges have been developed and if the soil has been limed to pH 5.6 or more.

A flexible roller, packer, or harrow that follows the contour of the ridge and is pulled behind the drill will firm the ridges or beds, enhance germination, and reduce the possibility of herbicide injury to wheat seedlings. The beds must have a crown to encourage surface water runoff.

Since most of these poorly drained lands are badly infested with annual ryegrass, fall weed control is imperative. Apply diuron at 1¼ to 2 pounds per acre as soon as early rains have settled the surface soil on the ridges. Dichlofop (Hoelon), applied in December or January at the rate of ¾ to 1 pound per acre, will control annual ryegrass and wild oats.

Ridging of poorly drained fields can be effective only if the water collecting in swales and the lowest portions of the fields is drained by temporary ditches or waterways. If excess surface water is allowed to pond over the ridges, this method of planting will fail.

Prepared by N. R. Goetze, Extension agronomist; Michael Stoltz, Lane County Extension agent; and T. L. Jackson, Extension soil science specialist.

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FS 250 September 1980

Combating Take-All Root Rot of Winter Wheat in Western Oregon

Take-all root rot of wheat (*Gaeumannomyces graminis* var. *tritici*) has increased dramatically in western Oregon under high rainfall and irrigation. The increased frequency of wheat planting in crop rotations increases the disease. Take-all produces a darkened, black, infected root system and lower stem; mature plants may be stunted and yellow, and may produce white heads and shriveled kernels. Effective fungicide treatments are not available, and there are no varieties with effective resistance to the disease. Careful management can help reduce the problem.

Conditions and Practices that Affect the Disease

Tests conducted by Oregon State University show that the occurrence and extent of damage caused by take-all disease in western Oregon wheat is affected by the following:

► Early planting, especially before October 10, increases take-all and most other winter wheat diseases in western Oregon. The authors recognize the risk of late planting on moderately to poorly drained soils. The risk is that the wet weather that often comes in November and December can drown young seedlings. Small plants are more susceptible to water damage and herbicide injury.

Planting on ridges, and surface leveling to reduce water accumulation around the crown of plants, will reduce adverse effects of water. Save the better drained fields with a take-all potential for late plantings. Plant fields with low take-all potential first.

► Dry soil conditions and low temperatures after planting delay take-all infection and emergence of wheat; warm winter temperatures encourage take-all.

► Moist soils, especially in the spring, increase take-all severity by favoring fungus spread throughout the root system. Poor drainage around the crown of the plant reduces new root growth and tillering.

► Wheat following wheat increases take-all and some grasses are a host to the fungus. A wheat-legume-wheat, or wheat-barley rotation can result in severe take-all. Legume rotations increase nitrate-N at planting; this increases disease severity.

Take-all grass relationships: wheat following ryegrass generally has been free from take-all for 2 or 3 years.

Ryegrass, meadow fescue, and orchardgrass generally reduce the disease. Bentgrass, bluegrasses, and quackgrass host the disease and encourage infection of wheat.

► The form of nitrogen (N) fertilizer affects the disease. Ammonium (NH_4) nitrogen decreases take-all, while nitrate (NO_3) nitrogen increases it. Thus, increased frequency of wheat plus management practices or crop sequences that increase NO_3-N increase take-all. Incorporating crop residues with low N concentrations immobilizes available NO_3-N, but applying a high N rate (60 to 100 pounds nitrogen per acre) about September 1 to speed decomposition of straw could increase the supply of NO_3-N during seedling growth and increase take-all. Application of 300 pounds nitrogen per acre (N/A) as sewage sludge on wheat straw about September 20 increased take-all root rot dramatically in 1980 experiments. Also, nitrification inhibitors such as N-Serve, Dwell, etc., will help maintain N as NH_4-N and has decreased take-all.

► Phosphorus (P) fertilizers: acid soils, disease problems, and cold weather (winter damage as in 1978-79) favor P response on soils normally considered well supplied with P. Application of P banded with the seed has consistently reduced take-all root rot on soils with both low and high P soil test values when the disease is present in western Oregon.

► Liming moderately acid soils (pH 5.6 to 5.8) has increased take-all. Liming increased take-all at the North Willamette Experiment Station, where the unlimed plots had a pH of 5.8. However, liming reduced take-all in Douglas County where the soil pH was 5.3. This might be interpreted as follows: a) Liming moderately acid soils might enhance conversion of NH_4-N to NO_3-N and thus increase take-all; many soils are limed above pH 6.0 for production of some vegetable crops and legumes. b) On severely acid soils, aluminum and manganese toxicity and decreased P uptake will reduce vigor of root systems. Liming these soils may favor wheat plants more than the fungus.

Prepared by T. L. Jackson, R. L. Powelson, and N. W. Christensen. Jackson is Extension Soils Specialist and professor of soil science, Powelson is professor of plant pathology, and Christensen is assistant professor of soil science, Oregon State University.

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▶ Banding chloride fertilizers with or near the seed at planting has reduced take-all. Reduction in disease severity was greater in 1978 and 1980 than in 1979. However, take-all was widespread in 1978 and 1980.

Field experiments (1977, 78, 79, 80) showed a reduction in take-all root rot when ammonium chloride (NH_4Cl), or NH_4Cl + potassium chloride (KCl) or sodium chloride (NaCl) and/or NPK fertilizers were banded with the seed. Also, NH_4Cl or ammonium sulfate plus KCl has reduced take-all in greenhouse pot experiments.

Banding any fertilizer salt with the seed at planting time can delay emergence and may reduce stands. Low soil moisture, salt index of the fertilizer, high temperatures, sandy soils, and high rates of fertilizer application affect this delayed emergence and stand reduction.

Western Oregon soils generally approach field capacity by October 10. A mixture of 25 pounds N/A as NH_4Cl plus 40 pounds K_2O/A as KCl has been banded with the seed with good results when soils are moist. However, with dry soils as in October 1978, emergence was delayed and in many cases stands were reduced when these rates of NH_4Cl plus KCl were banded with the seed in early to mid-October.

▶ Spring application of chloride fertilizers has increased yields; broadcast sodium chloride, potassium chloride, and ammonium chloride in the spring has reduced leaf diseases in 1980. We don't know how consistent this effect will be; also, leaf diseases vary from year to year. Optimum rates of Cl application have not been established.

▶ Take-all decline (TAD) develops after 4 to 7 years of continuous wheat. In most cases this requires one or two badly infected wheat crops. TAD is a biological system that affects activity of the take-all fungus. Once TAD is established, a break in continuous wheat production destroys the TAD.

Barley hosts the fungus and acts like a wheat crop in increasing build-up of the fungus as well as take-all decline. One possibility to establish TAD with continuous wheat would be to grow wheat until take-all develops, then grow winter barley for 2 or 3 years, and then go back to continuous wheat.

Management Recommendations

A number of management practices reduce take-all root rot. None will eliminate it fully. Key the management around the things that affect take-all:

- Crop rotation or crop sequence.
- Planting date.
- Winter soil temperatures.
- Soil drainage and soil moisture.
- Soil fertility.
- Liming or soil pH.
- Source of N.
- Chloride fertilizers.

Recommendations for western Oregon fields where take-all root rot is expected include:

▶ Plant after October 15. Planting after this date would be better if you are willing to risk adverse effects of heavier than normal November and December rains. Later planting reduces all wheat disease in western Oregon.

▶ Priority for western Oregon planting dates, early to late.

- First year wheat on poorly drained soils—plant first.
- First year wheat on well drained soils.
- Continuous wheat where take-all decline has eliminated the disease.
- Second, third, or fourth wheat crop on poorly drained soils.
- Second, third, or fourth wheat crop on well drained soils—plant last.

▶ Band fertilizer with the seed at planting. Salt damage can delay emergence and reduce stands where soils are dry and soil temperatures are 70° to 80° F or higher. With normal Willamette Valley soil moisture and temperatures for October, fertilize as follows: (Application rates are pounds per acre (lbs/A), banded with the seed).

Fertilizers recommended at planting time:

- 20 to 30 lbs/A ammonium (NH_4) N.
- 40 to 50 lbs/A phosphorus (P_2O_5).
- 30 to 40 lbs/A of chloride.
- 5+ lbs/A of sulfur—optional if 30 to 40 lbs/A of S was applied in past year.
- 30 to 40 lbs/A of potassium (K_2O) where soil tests indicate need or to supply chloride when other sources of chloride are not applied.

Application Alternative #1

100 lbs/A of ammonium chloride.
25 lbs/A of ammonium sulfate.
100 lbs/A of conc. superphosphate.

Application Alternative #2

200 lbs/A 16-20-0 ammonium phosphate-sulfate.
75 lbs/A potassium chloride.

Application Alternative #3

200 lbs/A of mixed fertilizer materials to supply 25 to 30 lbs. of N, 40 to 45 lbs. P_2O_5, 40 lbs. K_2O (as potassium chloride)

#1 gives less salt effect per pound of N and chloride applied.

▶ Do not include urea, diammonium phosphate, ammonium nitrate, or calcium nitrate with materials banded with the seed at planting.

▶ Include nitrification inhibitors with fall applied ammonium (NH_4) nitrogen where equipment is available.

▶ Spring application of N. The potential for take-all does not change the standard recommendations for spring application of N.

▶ *On a trial basis,* include 75 to 100 pounds of chloride in spring applications. (Spring broadcast application of chloride reduced leaf diseases in 1980).

Chloride can be supplied by:

- Ammonium chloride—66% Cl.
- Potassium chloride—47% Cl.
- Sodium chloride—60% Cl.
- Calcium chloride—64% Cl.
- Magnesium chloride—74% Cl.

Herbicides for Annual Weed Control in Wheat in Eastern Oregon

More than 40 different kinds of broadleaf weeds and grasses can be found in most eastern Oregon cereal fields. Many of these weeds are resistant to one or more of the commonly used herbicides. The continued use of the same herbicide year after year will select for resistant species present in the field. The best way to avoid build-up of herbicide-resistant species is to rotate the use of a herbicide at least once every third season. The wide selection of herbicides and herbicide combinations now available would make a chemical rotation feasible.

Eleven registered herbicides and five combinations with state registrations, for a total of sixteen, are available for broadleaf weed control. Trifluralin (Treflan) is registered as a downy brome (cheatgrass) herbicide for winter wheat, and is also effective on bulbous bluegrass *(Poa bulbosa)* and occasionally effective on goatgrass *(Aegilops cylindrica)*. Trifluralin is only effective as a preplant soil-incorporated material. *Wheat must be seeded below the trifluralin-treated zone to prevent severe injury or stand loss.*

Soil-active herbicides such as chlorbromuron (Maloran), diuron (Karmex), linuron (Lorox), metribuzin (Sencor or Lexone), and terbutryn (Igran) normally are used in the fall after the grain has emerged and when sufficient rain has occurred to firm the soil surface. Do not apply before the crown root system is well developed or damage may result.

Bromoxynil-dicamba, bromoxynil-diuron, bromoxynil-linuron, bromoxynil-metribuzin, and bromoxynil-MCPA combinations are used after weeds have emerged in late winter or early spring. The combinations generally are applied after the wheat has emerged but before the weeds have established a deep root system. Applications made after March 1 are less effective.

All 2,4-D and 2,4-D-dicamba materials are commonly applied in the spring after the wheat is well established, preferably in the four- to six-tiller stage. MCPA can be applied any time after the wheat has three to four tillers. Applications of most phenoxy materials must be delayed until the wheat is tillered; the weeds are often too large for effective control at this time, thus limiting the potential yield.

Bromoxynil (Buctril or Brominal) and dinoseb (salt formulations) can be used any time in the fall or early winter after the broadleaves have emerged but before they are beyond the seedling stage (2- to 6-leaf).

Metribuzin is a postemergence herbicide registered for the selective control of downy brome in winter wheat and winter barley but is partially effective on ripgut brome (*Bromus rigidis*), and bulbous bluegrass (*Poa bulbosa*). Metribuzin is effective as a postemergence treatment after wheat or barley have three tillers and well developed crown roots. Downy brome is sensitive to metribuzin in the seedling stage (3- to 4-leaf) but becomes resistant when growth exceeds 4 tillers.

Some unregistered herbicides show promise of aiding the weed control program and new mixtures are being developed. Some are promising for the control of hard-to-kill broadleaf weeds and downy brome. In addition, mixtures are being developed that will reduce chemical residues in crops and soil and provide the grower with a larger economic advantage.

Good weed control requires selection of the proper herbicide and uniform application. Selection is based on the weed species present and their stage of growth, age of the grain, and soil type. Application uniformity partially determines the effectiveness of the selected herbicide. Spray nozzles on both aircraft and ground rigs should be adjusted carefully to prevent a distortion of the spray pattern within the swath. This is necessary to prevent high and low deposit zones which show up as streaks or skips in the field. Check the label on the container or get additional information from qualified weed control authorities.

The following table shows the relative performance of several herbicides and mixtures under eastern Oregon conditions. In some situations, weed control may be more or less effective than recorded. Since this is only a guide, additional information should be obtained from qualified agents, dealers, or research investigators.

Prepared by Donald J. Rydrych, associate professor of agronomy, and Ralph E. Whitesides, Extension agronomist, Oregon State University.

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HERBICIDE EFFECTIVENESS ON ANNUAL WEEDS IN EASTERN OREGON

Rating Scale: **E = excellent (95-100%), G = good (80-94%), F = fair (60-79%), P = poor (less than 59%), ... = resistant species, — = limited information**

	Foliar and Soil Active								Translocated		Contact		Combinations					
WEED GROUP	Chlorbromuron (Maloran)	Diclofop (Hoelon)	Diuron (Karmex)	Linuron (Lorox)	Metribuzin (Sencor or Lexone)	Terbutryn (Igran)	Trifluralin (Treflan)	2,4-D	Dicamba + 2,4-D	MCPA	Bromoxynil	Dinoseb (salt formulations)	Bromoxynil + dicamba	Bromoxynil + MCPA	Bromoxynil + MCPA + dicamba	Diuron + bromoxynil	Linuron + bromoxynil	Metribuzin + bromoxynil
Borage																		
Fiddleneck *(Amsinckia intermedia)*	E	P	E	E	F	E	P	F	G	F	G	P	E	E	E	E	E	F
Common bugloss (Alkanet) *(Anchusa officinalis)*	E	P	E	E	G	E	G	P	F	P	G	P	E	G	E	E	E	E
Corn gromwell *(Lithospermum arvense)*	E	P	E	E	P	G	F	P	F	P	G	P	E	E	E	E	E	P
Madwort (Catchweed) *(Asperugo procumbens)*	P	P	P	P	F	F	F	F	F	P	P	F	G	G	G	G	G	G
Buckwheat																		
Prostrate knotweed *(Polygonum aviculare)*	P	P	P	P	G	P	G	P	G	P	P	F	E	G	E	F	G	G
Wild buckwheat *(Polygonum convolvulus)*	P	P	P	P	P	P	P	P	F	P	P	P	F	P	F	P	P	P
Buttercup																		
Testiculate buttercup (Horned-head) *(Ranunculus testiculatus)*	G	P	G	G	PF	P	G	P	F	P	P	F	G		F	G	G	G
Carrot																		
Bur beakchervil *(Anthriscus scandicina)*	F	P	P	F	P	F	—	P	F	E	P	F	E	G	E	P	F	P
Poison hemlock *(Conium maculatum)*	F	P	F	G	P	F	P	F	G	P	P	P	F	F	F	P	P	P
Figwort																		
Ivyleaf speedwell *(Veronica hederaefolia)*	F	P	P	F	E	F	G	P	F	P	P	E	F	P	F	P	P	E
Geranium																		
Redstem filaree *(Erodium cicutarium)*	F	P	F	F	F	G	G	F	F	F	P	G	G	F	G	G	G	F
Goosefoot																		
Russian thistle *(Salsola kali)*	P	P	P	P	F	P	F	G	G	P	P	P	F	F	G	P	F	F
Common lambsquarters *(Chenopodium album)*	G	P	G	G	E	G	E	E	E	G	F	G	E	E	E	G	G	E
Kochia *(Kochia scoparia)*	G	P	G	G	E	E	E	G	E	G	F	G	E	E	E	G	G	E
Mustard																		
Smallseed Falseflax *(Camelina microcarpa)*	G	P	G	G	G	G	P	G	G	F	G	G	E	E	E	G	E	E
Shepherdspurse *(Capsella bursa-pastoris)*	G	P	G	G	G	F	P	G	E	F	F	G	E	G	E	G	G	G
Blue mustard (Purple) *(Chorispora tenella)*	E	P	E	E	G	G	P	F	G	P	G	P	F	G	G	E	E	G
Tansymustard *(Descurainia pinnata)*	G	P	G	G	G	P	P	G	G	F	G	F	G	G	G	G	G	G
Bushy wallflower *(Erysimum repandum)*	E	P	G	E	F	F	P	F	G	P	G	G	E	E	E	G	G	F
Yellowflower pepperweed *(Lepidium perfoliatum)*	E	P	E	E	G	G	P	E	E	F	G	G	G	G	E	G	G	G
Tumble mustard (Jim Hill) *(Sisymbrium altissimum)*	F	P	F	F	F	P	P	E	E	G	F	F	E	E	E	E	E	F
Field pennycress (Fanweed) *(Thlaspi arvense)*	E	P	F	G	G	G	P	E	E	G	F	F	E	E	E	E	E	E
Wild mustard *(Brassica spp.)*	G	P	G	G	G	G	P	E	E	G	P	P	F	G	E	F	G	F

WEED GROUP	Foliar and Soil Active							Translocated			Contact		Combinations					
	Chlorbromuron (Maloran)	Diclofop (Hoelon)	Diuron (Karmex)	Linuron (Lorox)	Metribuzin (Sencor or Lexone)	Terbutryn (Igran)	Trifluralin (Treflan)	2,4-D	Dicamba + 2,4-D	MCPA	Bromoxynil	Dinoseb (salt formulations)	Bromoxynil + dicamba	Bromoxynil + MCPA	Bromoxynil + MCPA + dicamba	Diuron + bromoxynil	Linuron + bromoxynil	Metribuzin + bromoxynil
Madder																		
Catchweed bedstraw (cleavers) *(Galium aparine)*	G	P	G	G	F	E	G	P	P	P	F	F	G	F	F	G	G	F
Mint																		
Henbit (dead nettle) *(Lamium amplexicaule)*	G	P	G	G	E	E	G	P	F	F	F	E	G	F	G	G	G	E
Purslane																		
Minerslettuce *(Montia perfoliata)*	G	P	G	G	F	G	F	P	F	P	F	F	F	F	F	G	G	F
Pea																		
Hairy vetch *(Vicia villosa)*	P	P	P	P	P	P	P	E	E	F	P	P	P	F	F	P	P	P
Pink																		
Corn cockle *(Agrostemma githago)*	F	P	F	F	G	F	F	P	E	P	F	P	G	G	E	E	E	G
Cow cockle *(Vaccaria segetalis)*	F	P	F	F	F	F	F	P	G	F	F	P	G	G	G	G	G	F
Jagged chickweed (Umbel chickweed) *(Holosteum umbellatum)*	F	P	F	F	F	F	E	P	G	P	P	F	F	F	F	F	F	G
Knawel *(Scleranthus annuus)*	F	P	G	G	P	P	G	P	G	F	F	F	F	F	G	G	G	F
Polemonium																		
Annual polemonium (Jacobs ladder) *(Polemonium micranthum)*	G	P	G	G	G	G	G	G	G	G	P	F	G	F	E	G	G	G
Sunflower																		
Annual sowthistle *(Sonchus oleraceus)*	F	P	F	F	G	G	P	E	E	F	F	F	G	G	G	F	F	F
Prickly lettuce *(Lactuca scariola)*	F	P	P	F	G	G	F	E	E	G	F	G	G	G	E	G	G	G
Mayweed (Dog fennel) *(Anthemis cotula)*	G	P	E	G	F	G	G	P	G	P	P	F	F	F	G	F	F	G
Pineappleweed *(Matricaria matricarioides)*	F	P	G	G	P	G	G	P	F	P	G	P	F	G	F	F	F	P
Cornflower (Bachelor button) *(Centaurea cyanus)*	G	P	G	G	F	F	F	F	F	P	F	P	F	G	G	G	G	F
Grasses																		
Downy brome (Cheatgrass) *(Bromus tectorum)*	P	E**	P	P	E	*	G	...	...	...	...	P	...	...	...	P	P	E
Ripgut brome *(Bromus rigidus)*	P	G**	P	P	G	P	G	...	...	...	...	P	...	...	...	P	P	G
Wild barley (foxtail) *(Hordeum leporinum)*	P	F	P	P	E	P	G	...	...	...	...	P	...	...	...	P	P	E
Barnyardgrass (watergrass) *(Echinochloa crus-galli)*	G	G	F	G	E	F	E	...	...	...	...	P	...	...	...	P	P	E
Bulbous bluegrass *(Poa bulbosa)*	P	G**	P	P	G	P	F	...	...	...	...	P	...	...	...	P	P	G
Jointed goatgrass *(Aegilops cylindrica)*	P	P	P	P	P	P	F	...	...	...	....	P	...	...	...	P	P	P
Wild oat *(Avena fatua)*	P	E	P	P	P	P	F	...	...	...	...	P	...	...	...	P	P	P
Witchgrass *(Panicum capillare)*	P	E	P	P	G	F	G	...	...	...	...	P	...	...	...	P	P	G
Italian ryegrass *(Lolium multiflorum)*	P	E	P	P	F	P	G	...	...	...	...	P	...	...	...	P	P	F

* Erratic
** Must be soil-incorporated

Forages in Oregon

The following pages contain information about commonly grown forage crops in Oregon. The information provided is from Oregon State Univesity Extension bulletins. The bulletins presented include:

1.	Growing Perennial Ryegrass for Forage	FS 262
2.	Growing Orchardgrass for Forage	FS 261
3.	Growing Tall Fescue for Forage	FS 263
4.	Growing Birdsfoot Trefoil for Forage	FS 259
5.	Growing Subterranean Clover for Forage	FS 257
6.	Growing White Clover for Forage	FS 256
7.	Growing Alfalfa for Forage	FS 253
8.	Growing Reed Canarygrass for Forage	FS 265
9.	Growing Meadow Foxtail for Forage	FS 264
10.	Growing Kentucky Bluegrass for Forage	FS 260
11.	Growing Timothy for Forage	FS 266
12.	Growing Alsike Clover for Forage	FS 254
13.	Growing Red Clover for Forage	FS 255
14.	Growing Big Trefoil for Forage	FS 258

In addition to the Extension "Growing Forage" series also provided for Forage Crops instruction in Oregon are the following:

A. Alfalfa Production

1.	Growing Alfalfa in Western Oregon	EC 806
2.	Verticillium Wilt of Alfalfa	EC 1002
3.	Weed Control in Alfalfa	FS 267
4.	Fertilizer Guide - Alfalfa(Willamette Valley)	FG 18
5.	Fertilizer Guide - Alfalfa (Southwest Oregon)	FG 60
6.	Fertilizer Guide - Alfalfa (Eastern Oregon)	FG 20
7.	Enterprise Data Sheet - Alfalfa Hay, Mid-Willamette Valley	
8.	Enterprise Data Sheet - Alfalfa Hay, Klamath Basin	
9.	Enterprise Data Sheet - Alfalfa, Hermiston Area	

B. Pasture Production

1.	Pasture Management in Western Oregon	EC 1077
2.	Range and Pasture Management in Central and Eastern Oregon	EC 1092
3.	Pasture Management for Control of Tansy Ragwort	PNW 210
4.	Fertilizer Guide - Perennial Grass Pasture Western Oregon	FG 16
5.	Fertilizer Guide - Irrigated Clover - Grass Pastures (Western Oregon)	FG 1
6.	Fertilizer Guide - Irrigated Pastures - (Central Oregon)	FR 38

7.	Fertilizer Guide - Irrigated Clover - Grass Pastures (Eastern Oregon)	FG 21
8.	Fertilizer Guide - Native Meadows	FR 22
9.	Enterprise Data Sheet - Improved Dryland Pasture (Willamette Valley)	
10.	Enterprise Data Sheet - Improved Hill-Land Pastures (Willamette Valley)	
11.	Enterprise Data Sheet - Irrigated Pasture (Coos County)	
12.	Enterprise Data Sheet - Hill Pasture (Coos COunty)	
13.	Enterprise Data Sheet - Irrigated Pasture (Jackson & Josephine County)	
14.	Enterprise Data Sheet - Meadow Hay (Baker County)	

FS 262
June 1981

Growing Perennial Ryegrass for Forage

Area of Adaption

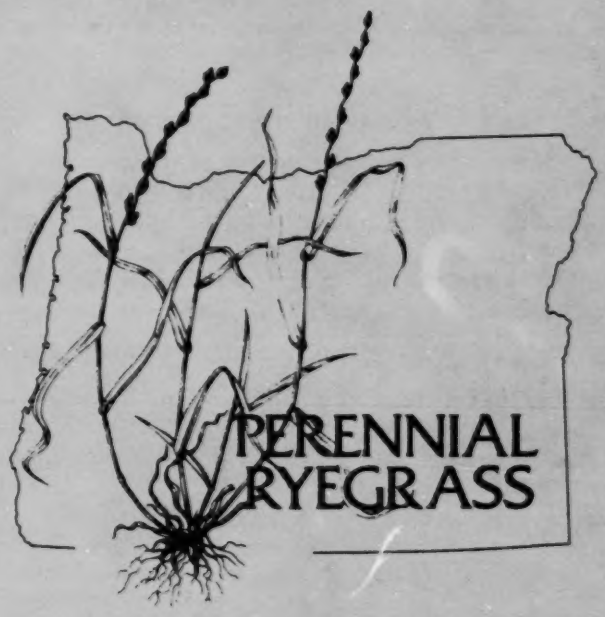
Perennial ryegrass *(Lolium perenne)* is a major forage grass which is used in cool, temperate climates throughout the world. In Oregon, it is adapted to areas west of the Cascade Mountains but is less winter-hardy than orchardgrass or tall fescue. For this reason it is not often recommended for use east of the Cascades.

Primary Use

Perennial ryegrass is commonly used for pasture and hay in sheep, dairy, and beef production. It is most often used in combination with white clover or subclover. When ryegrass is seeded with either of these clovers, the mixed pasture makes an excellent quality feed for the grazing animal. Perennial ryegrass does not persist as long as some other pasture species, but it is quite satisfactory for several years. Tetraploid ryegrasses have been developed recently for use as an ingredient of short-rotation dairy pastures.

Varieties

Linn is a relatively long-lived variety that has been used successfully in Oregon for many years. Astor is a variety that has been used for dairy pastures on the Oregon coast. Several proprietary varieties are also available from private seed companies.



Recent developments in plant breeding have resulted in tetraploid ryegrass varieties. Autotetraploids (produced by duplication of the chromosome sets from one species) will have perennial characteristics. However, allotetraploids (produced by combining chromosomes from two species—perennial and annual) are likely to be short-lived and should only be used in short-rotation pastures (2-4 years).

Use	Precipitation	Perennial ryegrass seeding rate	Companion species	Companion species seeding rate
	Inches	*Lbs/A*		*Lbs/A*
Pasture	Irrigated	10-12	White clover	2-3
	> 60	10-12	White clover	2-3
	40-60	10-12	White clover or subclover	2-3 7
	< 40	10	Subclover	7-10
Short-rotation pasture	> 40 or irrigated	(tetraploid) 10-12	White clover plus red clover	2 4

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Establishment

Perennial ryegrass may be fall seeded in areas with relatively mild winters. Seed should be planted in late summer before the fall rains begin. Spring seeding is possible where adequate moisture is available for seedlings to develop before the arrival of dry summer conditions. Seed should be planted ¼ to ½ inch deep in a well-prepared seedbed.

Fertility and pH Requirements

Perennial ryegrass requires high fertility levels for good production. If ryegrass is grown in combination with a nitrogen-fixing legume, it will not be necessary to apply nitrogen, but adequate levels of phosphorus and sulfur should be provided. Best growth will occur between pH 5.5 and 6.5. Specific recommendations based upon soil data are available in OSU Fertilizer Guides 1, 4, 16, and 58, depending upon the location and use of the pasture.

Management

In order to obtain the highest quality forage, clover-grass pastures should be grazed between 2 and 6 inches high to prevent the grass from shading the clover. Pastures are often grazed early in the season, and some areas are reserved for hay when growth exceeds the demand. For highest quality, hay should be cut when the inflorescence is emerging from the leaf sheath and certainly before flowers begin to shed pollen.

Spring application of nitrogen will stimulate early growth of the grass but will reduce the amount of clover in the pasture. Clovers are favored by continued close grazing (to 2 inches), adequate levels of phosphorus and sulfur, and no nitrogen applications. If clovers disappear from the pasture, they may be re-established by renovation techniques.

By David B. Hannaway, Extension agronomist, and William S. McGuire, professor of agronomy, Oregon State University.

FS 261
June 1981

Growing Orchardgrass for Forage

Area of Adaption

Orchardgrass *(Dactylis glomerata)* is distributed through much of the northeastern and north-central United States and in the high rainfall and irrigated regions of the western mountains. It is often found growing along roadsides and in waste areas. Its tolerance of shady places in orchards undoubtedly led to its most widely known common name. Orchardgrass is known as "cocksfoot" in Europe, New Zealand, and Australia. This name was derived from the shape of its inflorescence.

Primary Use

Orchardgrass is used primarily as a hay or pasture crop and in combination with various legumes. It is a highly productive grass with a good production distribution throughout the year when maintained under high fertility levels. At high levels of nitrogen (without legumes) orchardgrass is among the most productive cool-season grasses. Orchardgrass is more tolerant of heat and drought than perennial ryegrass, timothy, or Kentucky bluegrass but less so than tall fescue. Winter production of orchardgrass is usually less than that of perennial ryegrass or tall fescue as orchardgrass is more affected by frost.

Varieties

Orchardgrass breeders have concentrated on developing varieties that mature later than com-

Use	Precipitation	Orchardgrass seeding rate	Companion species	Companion species seeding rate
	Inches	*Lbs/A*		*Lbs/A*
Pasture	> 60	10-12	White clover	2-3
	40-60	10-12	White clover	2-3
		10-12	Subclover	7
	< 40 or	10-12	Subclover	7-10
	irrigated	10-12	White clover	2-3
		7	Birdsfoot trefoil	6
Hay	40-60	5-6	Alfalfa	10
		12-15	-------	----

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mon orchardgrass, are more productive, and more resistant to disease. Potomac is an early variety, Pennmead and Sterling are intermediate, and Pennlate and Latar are late maturing varieties. When used in combination with alfalfa, late maturing varieties are preferred to better coincide with the harvest date of alfalfa.

Establishment

When used in its area of adaption, orchardgrass is easily established. Orchardgrass can be established in early spring or late summer. Seeding rates and suggested combination species are shown in the table on page 1. The seedbed should be loose on top and firm below a depth of 2 inches. Seed should be planted ½ inch deep. If clover is mixed with orchardgrass, a planting depth of ¼ inch is sufficient. The use of a press wheel or cultipacker will help to ensure stand survival when orchardgrass is planted on a dry seedbed. Seedling growth may be retarded by inadequate levels of phosphorus in the soil.

Fertility and pH Requirements

If used without a legume, orchardgrass is very responsive to nitrogen fertilization. Yield responses to phosphorus and potassium fertilization have also been demonstrated for orchardgrass. Best growth will occur between pH 5.5 and 6.5 as orchardgrass is less tolerant of soil acidity than many other pasture grasses. Specific recommendations on fertilizer application based upon soil test information are found in OSU Fertilizer Guides 1, 16, 28, and 58.

Management

Highest yields of good-quality forage are obtained when orchardgrass hay is cut between head emergence and early bloom. Delaying harvest an additional 2 weeks will decrease aftermath harvest by one-fourth in addition to reducing the quality of hay cut at a late stage of maturity. Orchardgrass stands become thin and clumpy when first growth is cut late. However, stand longevity is not adversely affected by late cutting.

Regrowth of orchardgrass depends upon photosynthetic activity and carbohydrate reserves. When root reserves are high, close cutting or grazing does not adversely affect the stand. However, when reserves are low, close cutting is a severe management practice. Thus, cutting several times at ground level or continuous close grazing almost always results in serious stand injury. Injury also may result from burning in areas where excess forage is removed in this way (in late summer) to allow subclover seedlings to become established during the fall.

When planted in combination with orchardgrass, clover is favored by close clipping or grazing because it receives less shading from the grass. Adequate levels of phosphorus, potassium, and sulfur also favor the clover in a mixed clover-grass pasture. The application of nitrogen, however, favors the grass and may result in the disappearance of clover from the pasture.

By David B. Hannaway, Extension agronomist, and William S. McGuire, professor of agronomy, Oregon State University.

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FS 263
June 1981

Growing Tall Fescue for Forage

Area of Adaption

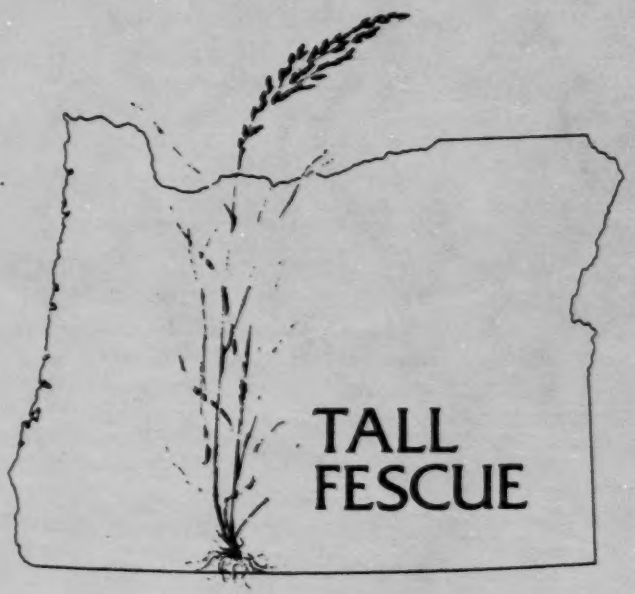
The extensive and rapid acceptance of tall fescue *(Festuca arundinacea)* since 1950 is a result of its wide adaption and valuable qualities as a pasture grass. Tall fescue is adapted to a wide range of climatic conditions and is heavily used in the central and southeastern United States. It is the only cool-season grass that can persist in many parts of the south.

Large quantities of tall fescue are produced for seed in Oregon, in addition to its use as a pasture grass throughout Washington and Oregon. Tall fescue, one of the most drought-tolerant forage grasses, is also tolerant of poor drainage, alkalinity, and salinity.

Primary Use

Tall fescue is used widely for forage, turf, and conservation purposes. It is the predominant cool-season grass in many states, where it is used extensively in pastures. Tall fescue produces most abundantly under irrigation and high fertility. It is tolerant of continuous close grazing and is superior to many other cool-season grasses in livestock-carrying capacity.

Tall fescue also can be used as a hay crop. When used for hay, tall fescue should be harvested when the first seed heads begin to appear.



Use	Precipitation	Tall fescue seeding rate	Companion species	Companion species seeding rate
	Inches	*Lbs/A*		*Lbs/A*
Pasture	< 40	15	Subclover	7
	40-60	15	Subclover	7
		15	White clover	2-3
	> 60	15	Big trefoil	2
		15	White clover	2-3
Wetland or irrigated pasture		15	White clover	2-3
		15	Birdsfoot trefoil	6
Hay	40-60	12	.....	.....
		12	Red clover	8
	> 60	12	White clover	2-3

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Varieties

Fawn and Alta are varieties of tall fescue that have been recommended in Oregon for many years. Kentucky 31 and Demeter have produced well in recent variety test evaluations. Kenhy, a ryegrass-fescue hybrid with improved palatability, has also performed well in these tests.

Establishment

When established, tall fescue has vigorous growth, but its seedling growth and establishment are somewhat slow. Therefore, a clean, firm seedbed is most desirable. Seed should be planted from ¼ to ½ inch deep, depending upon soil conditions. Tall fescue can be seeded either in late summer (before the fall rains start) or in spring. Better legume stands, however, usually are obtained with spring planting.

Fertility and pH Requirements

Tall fescue does best on soils of high fertility, but it is not difficult to establish under rather adverse soil conditions. It will establish on soils of low pH and will do well on a variety of soil types. Liming and fertilizing, on the basis of soil test information, are essential for a good stand of legume and will be satisfactory for good tall fescue growth. Specific recommendations may be obtained from OSU Fertilizer Guides 1, 16, 28, and 58.

Management

Since tall fescue is rather slow to establish, new stands can be seriously damaged by overgrazing or grazing too soon. However, close grazing of well-established stands is a good management practice. Tall fescue will withstand heavy grazing for short periods. Under irrigation and a rotational system of grazing, tall fescue recovers well. For best production and longevity, however, tall fescue should not be grazed closer than 2 inches.

The addition of a legume to tall fescue plantings increases the palatability and nutritive value of the pasture. Legume addition, however, makes managing these pastures more difficult as the legume will be selectively grazed. Unless livestock are forced to use the tall fescue through rotational grazing, the legume will be removed by overgrazing.

By David B. Hannaway, Extension agronomist, and William S. McGuire, professor of agronomy, Oregon State University.

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FS 259
June 1981

Growing Birdsfoot Trefoil for Forage

Area of Adaption

Species of *Lotus* are widely distributed throughout the world. Birdsfoot trefoil (*Lotus corniculatus*) is grown in the northeastern and north-central states and in the Pacific Northwest coastal and intermountain areas. It is suited to clay soils and areas that are too wet or too acid for alfalfa production.

Primary Use

Birdsfoot trefoil is a non-bloating legume that is suitable for use in permanent pastures or for use as a hay crop, either alone or sown in combination with grasses. When used for grazing, birdsfoot trefoil is used to best advantage in a rotational grazing system. When grown for hay on land that is suitable for alfalfa, birdsfoot will produce considerably less forage than alfalfa. For this reason, birdsfoot trefoil should be used only in areas that are *not* suitable for alfalfa production because of their acidity, poor drainage, or low fertility.

Varieties

Cascade and Granger are varieties developed for use in Oregon. Kalo, a dwarf English variety, is suitable for grazing, ground cover, or erosion control.

Establishment

Weak seedling vigor is the major problem encountered when establishing stands. Because birdsfoot trefoil has a relatively slow growth rate and small seed size, good seeding practices and weed control are essential. Seeding rates for various mixtures are indicated in the table. Seed should be covered slightly or planted ¼ inch deep.

Use	Precipitation	Birdsfoot trefoil seeding rate	Companion species	Companion species seeding rate
	Inches	*Lbs/A*		*Lbs/A*
Pasture	Irrigated	6	Orchardgrass	7
Wetland pasture	30-100	6	Tetraploid or annual ryegrass	4-5
Hay	Irrigated or 40-60	7-8 6	------ Orchardgrass	------ 7

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Planting seed above a band of fertilizer (band seeding) but not in contact with the fertilizer will enhance seedling vigor. Birdsfoot trefoil, like all legumes, should be treated before planting with the proper strain of *Rhizobium* bacteria that will fix atmospheric nitrogen. This nitrogen eliminates the need for using fertilizer nitrogen. Be sure to use the correct inoculum for birdsfoot trefoil (*Lotus corniculatus*), as the bacteria used for alfalfa or other legumes are not effective in nodulating birdsfoot trefoil. Even inoculum for other trefoil species will not effectively nodulate birdsfoot trefoil. Planting can take place in the early spring or late summer. Early spring planting is preferable because of ample soil moisture for germination and seedling development.

Fertility and pH Requirements

One of the major advantages of birdsfoot trefoil is its tolerance to low fertility and to low soil pH. However, maximum forage growth will occur on fertile soils with a pH of 6.0 to 6.2. A moderate application of phosphorus and sulfur at planting, based on soil test data, will provide for good growth.

Management

Early spring or continuous grazing of birdsfoot trefoil will weaken and eliminate a stand. Rotational grazing should be used, allowing animals to graze when the first flowers appear. For use as pasture, this will allow two grazing periods on dryland pastures west of the Cascade Mountains or three grazing periods on irrigated land.

If used as a combination of hay and pasture, a hay crop can be taken at early bloom (June) and the regrowth grazed at first flower. On irrigated areas, two regrowths can be expected and can be used as hay or pasture. The third hay crop, or grazing period, can be expected in September. Regrowth can be grazed in October and November.

Persistence

Birdsfoot trefoil is persistent and has a long life when managed properly. It is relatively free of insect and disease damage, and is very winter hardy once established. The most likely causes of loss of stand are continuous, hard grazing; competition through shading from too much grass and weeds; and excessively poor drainage such as standing water. Allowing some seed production during lenient grazing in summer will thicken the stand as the shattered seeds germinate quickly with irrigation or rain.

By David B. Hannaway, Extension agronomist, and William S. McGuire, professor of agronomy, Oregon State University.

FS 257
June 1981

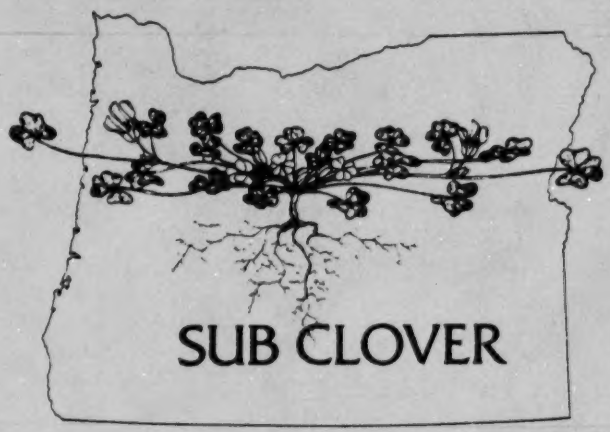
Growing Subterranean Clover for Forage

Area of Adaption

Subterranean clover *(Trifolium subterraneum)*, or subclover, is established on 25 million acres in Australia and is well adapted as a hill land pasture legume west of the Cascade Mountains in Oregon, in the interior hill country in California, and in parts of the southeastern United States. Subclover is especially well suited to areas that have warm, moist winters and dry summers, neutral to acid soils, and rainfall exceeding 15 inches.

Primary Use

Subclover is used as a pasture legume on non-irrigated hill land areas in combination with perennial grasses—ryegrasses, tall fescue, or orchardgrass. Perennial ryegrass is generally preferred for early, high-quality pasture, and the combination with subclover makes an excellent sheep pasture during spring and early summer. However, production is essentially finished by mid- to late June because of the dry summers in these hill land areas. Set-aside pastures and undergrazed pastures provide dry feed that is of sufficient quality for dry sheep and cows. This residue must be removed by grazing or burning to allow reseeded subclover seedlings to establish in the fall. In addition to the perennial grasses, 1 pound of white clover may be added in areas of high fertility with good soil moisture.



Varieties

Mt. Barker and Nangeela are midseason varieties that are suitable for areas with lower amounts of rainfall and for sites that become dry in June. Tallarook is a later variety that is more productive in areas with moisture into July, such as the Oregon coast and lower valley area.

Certain subclover varieties have high oestrogen concentrations. Oestrogen compounds (especially formononetin) in the leaves reduce the fertility of ewes grazing this forage. The previously listed cultivars are low in oestrogen. Other commercial varieties that are low in oestrogen are: Bacchus Marsh, Clare, Daliak, Larisa, Northam, Nungarin, Seaton Park, Trikkala, and Woogenellup. Large

Use	Precipitation	Subclover seeding rate	Companion species	Companion species seeding rate
	Inches	*Lbs/A*		*Lbs/A*
Hill land pastures	> 15	7-10	Perennial ryegrass	10-12
			Tall fescue*	10-12
			Orchardgrass	10-12

* Tall fescue used only on shallow or droughty soils.

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amounts of oestrogen in the forage may be harmful to sheep, but cattle and goats seem unaffected by these oestrogenic compounds.

Establishment

Seed is often aerially applied on burned or cleared land. If planted with a drill, seed should be placed not over ½ inch deep in a well-prepared, weed-free seedbed that is firm below a depth of 2 inches. As with all legumes, subclover should be inoculated with a specific *Rhizobium* bacteria to assure adequate nodulation. Initial working of the seedbed should be done sufficiently early to ensure adequate weed control and facilitate early sowing. The use of herbicides will reduce the period of fallow required. To obtain good establishment, cover seed with a light, trailing harrow or with band sowing attachments. Light rolling is recommended if soil is likely to dry out. Lime pelleting or liming is recommended on highly acid soils (below pH 5.5). Best results are obtained by sowing in September or early October to get plants established before winter.

Fertility and pH Requirements

Subterranean clover will tolerate acid soil conditions and medium poor drainage. However, subclover will not survive in standing water or in seepage areas. For highest production of subclover, soils should be well supplied with phosphorus and sulfur. If soils are low in pH, molybdenum may need to be applied. When seeds are well inoculated with suitable *Rhizobium*, no nitrogen is necessary for a vigorous stand of clover. Specific fertilizer recommendations based upon soil test data are provided in OSU Fertilizer Guides 4 and 63.

Management

Subterranean clover is an annual legume, and must reseed itself each year to ensure its continued presence in the pasture. In order for reseeding to be successful, residual top growth must be removed before the fall rains. This can be achieved by forced grazing or burning. This removal allows the seed that has been buried from this year's crop to germinate and become established in the fall.

Low stocking rates will prevent the re-establishment of subclover, resulting in a grass-dominant pasture. Increased stocking rates will help prevent weed invasion (except for various thistles). In addition, heavier stocking rates reduce the problem of summer forage removal. The best pasture management and animal production are obtained when pastures are grazed intensively. This, combined with adequate fertilization, will result in a high level of production of subclover-grass pastures.

By David B. Hannaway, Extension agronomist, and William S. McGuire, professor of agronomy, Oregon State University.

FS 256
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Growing White Clover for Forage

Area of Adaption

White clover (*Trifolium repens*) is found throughout the temperate regions of the world and is limited only by extreme cold or heat or by drought. Optimum performance of white clover as a pasture plant occurs in mild, humid climates. In the United States, white clover is found in the humid eastern half of the country and in the Pacific Northwest. It is also utilized in irrigated pastures throughout the intermountain region.

White clover can be used on wet areas of soils with low pH, but does best in well-drained silt loam and clay soils of pH 6.0 to 7.0. It does not tolerate saline or highly alkaline soils.

Primary Use

White clover is *the most important pasture legume* in temperate region pastures. It is almost always planted in combination with grasses for beef, sheep, or horse pastures.

Like other legumes, white clover improves the feeding value of a grass pasture. This is the result of its high voluntary intake, digestibility, and crude protein levels.

White clover is used widely in renovation of permanent pastures lacking legumes. White clover-grass mixtures also may be used for high-quality hay or silage.

Varieties

Ladino, New Zealand, and "common" white clover are the most frequently used varieties. Ladino is also known as giant or Italian white clover, as it usually grows to a height of 8 to 12 inches compared to 4 to 6 inches for common white clover. New Zealand white clover contains a greater quantity of cyanogenetic glucoside than Ladino. Because this is an effective slug repellent, it is preferred in areas where slug damage is

Use	Precipitation	White clover seeding rate	Companion species	Companion species seeding rate
	Inches	*Lbs/A*		*Lbs/A*
Pasture	60	2-3	Orchardgrass	10-12
		2-3	Tall fescue	15
	40-60 or irrigated	2-3	Perennial ryegrass	10-12
		2-3	Orchardgrass	10-12
		2-3	Tall fescue	15
	Wetlands	2-3	Tall fescue	15
Short-rotation pasture	40-60 or irrigated	2-3	Hybrid ryegrass and red clover	20 4

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common. The glucoside is not present in sufficient quantity to affect most livestock, but it may cause photosensitization in horses. Common white clovers are small, prostrate clovers with good winter hardiness, but they are not usually as productive as New Zealand or Ladino white clover.

Establishment

Soil preparation should provide a fine, firm, weed-free seedbed. Fall plowing followed by light working of the surface soil in the spring will produce an excellent seedbed. Spring seeding should be done early to allow 4 to 6 weeks of growth before the dry season arrives. A similar time should be allowed before the first freeze if seed is sown in late summer. Under irrigated conditions, timing is not as critical. Seed should be planted no deeper than ½ inch immediately following innoculation with the proper *Rhizobium*. Firming the soil following planting will aid in rapid establishment of the seedlings.

Fertility and pH Requirements

Liming to achieve a pH of 6.0 or using lime-pelleted seed is recommended. Adequate levels of potassium, phosphorus, and sulfur should be available, as white clover requires a high level of fertility for high production. Properly inoculated and nodulated white clover-grass pastures will not require the addition of nitrogen. Early spring application of small amounts of nitrogen (30-40 lbs.) will stimulate early growth of grass but will favor the grass over the legume. For specific fertilizer recommendations based on soil test data, consult OSU Fertilizer Guides 1, 21, and 58.

Management

The most difficult problem in managing white clover-grass pastures is maintaining the clover. Frequent defoliation during the period of maximum grass growth (early spring) encourages white clover by minimizing grass competition. Mixed pastures should be used before the grass reaches its maximum competition. Clipping or harvesting surplus forage in understocked pastures will help maintain the clover and control the grass and weeds.

If pastures are grazed continuously, the height of forage should be maintained at 2 to 6 inches, depending on the grass species. Fall management should allow adequate regrowth for rooting new stolons before the first freeze. Disappearance of white clover from pastures can be remedied by pasture renovation.

Bloat is often a problem for animals on pastures that contain a large proportion of white clover. Methods of controlling bloat in mixed clover-grass pastures include supplementing pastures with grass hay and intensive strip grazing. Bloat-preventative materials, which prevent rumen foam production, may be added to drinking water, applied as a top dressing on grain supplements, or added to salt-molasses blocks. The effectiveness of these methods depends upon animals obtaining a regular supply of bloat preventative.

By David B. Hannaway, Extension agronomist, and William S. McGuire, professor of agronomy, Oregon State University.

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FS 253
August 1981

Growing Alfalfa for Forage

Area of Adaption

Alfalfa (*Medicago sativa*), or lucerne, is worldwide in its distribution and is grown in many areas of the United States, accounting for nearly 30 million acres of production. A wide range of soil and climatic conditions are suitable for alfalfa, but for best production it requires a well-drained soil with nearly neutral pH and good fertility. Alfalfa can be grown in nearly all areas of Oregon but should not be expected to do well in poorly drained or acid soil or in areas where adequate water is not available.

Primary Use

Alfalfa is used primarily as a hay crop. It has the highest feeding value of all commonly grown hay crops when harvested at late bud or early flower stage of maturity. Alfalfa produces the greatest amount of protein per acre of any livestock feed. It is often used in combination with corn silage in livestock rations to take advantage of the protein and energy content of the two feeds. Alfalfa also can be made into silage, pellets, meal, or cubes. With careful management, alfalfa can be used successfully as a pasture crop.

Varieties

Many varieties of alfalfa are available with specific characteristics for climatic, edaphic, and insect and disease problems. Winter-hardy, moderately hardy, and Flemish-type varieties are available for the different climatic regions of Oregon. Consult your county agent for varieties that will do well in your area.

Establishment

Alfalfa requires a deep, permeable soil with an adequate moisture supply during the growing season for maximum yields. It is *very* sensitive to poor drainage and compacted soil conditions that restrict root growth. Thus, alfalfa is most productive on loam or loamy soils that are both well drained and have good moisture-holding capacity. Alfalfa does not tolerate acid soils, especially in the seedling stage.

A good seedbed for alfalfa is finely pulverized, leveled, and firmed to the seedling depth and contains soil moisture near the surface to initiate germination. Leveling the field to eliminate dead furrows and low spots will result in a more uniform stand and ease equipment travel for the life of the stand.

The proper time for seeding alfalfa is determined by seasonal temperature and moisture conditions. Spring seeding should be made early enough to allow good root

Use	Precipitation	Alfalfa seeding rate	Companion species	Companion species seeding rate
	Inches	*Lbs/A*		*Lbs/A*
Hay and	30-60 or	12-15	------	------
silage	irrigated	10	Orchardgrass	5-6
Pasture	30-60	10	Timothy	4
		10	Orchardgrass	5-6
	12-40	4	Tall wheatgrass	15

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systems to form before high temperature and low moisture conditions slow growth rates.

Late summer and fall seedings must be made early and have sufficient soil moisture to allow enough growth to minimize loss of stand from winter injury.

Alfalfa seed must be placed in contact with moist soil. Seedlings are unable to emerge from the soil if planted too deep. For best seedling survival, drill seeds approximately ¼ inch deep. Seedling emergence is greatly reduced when seeds are planted deeper than ½ inch.

A seeding rate of 12 pounds per acre planted in 6-inch rows is usually sufficient for a good stand of alfalfa. However, higher seeding rates are sometimes used to compensate for poor soil preparation or seeding methods.

Inoculation

The presence of effective nodules on the roots of the plants is *essential* to a vigorous, productive stand. These nodules are formed by bacteria (*Rhizobium meliloti*) that are able to fix nitrogen from the air for use by the alfalfa plants. These bacteria may be present in fields where alfalfa has been grown recently, but all strains of bacteria are not equally effective. All alfalfa seed should be inoculated with a fresh commercial inoculum *immediately prior* to seeding, regardless of cropping history of the land or any previous inoculation of the seed. Inoculated seed should be kept cool and moist until planted.

Fertilization and pH Requirements

A productive alfalfa crop is a heavy user of plant nutrients. A complete fertilizer program is essential to a long-lived stand. A soil test is the first step in planning a fertility program. Applications of fertilizer and lime should be based on the results of a soil test. Lime applications are required on soils having a pH below 6.0

Apply lime well in advance of seeding, mixing thoroughly with the surface 6 inches of soil. Fall applications provide time for soil reaction to take place and avoid the spring rush that will often delay planting.

Phosphorus can be applied by banding ½ to 1 inch to the side or below the seed when seeding, but is most often applied by broadcasting, followed by shallow incorporation, just prior to seeding.

Potassium, sulfur, and boron should be worked into the seedbed just prior to the seeding operation. Potassium and boron should *not* be banded near the seed.

Nitrogen fertilizer is not required on legume forages because of the fixation of atmospheric nitrogen by effective nodules. Addition of nitrogen fertilizer will reduce the effectiveness of the natural nitrogen-fixing mechanism. Specific fertilizer recommendations based upon soil test data are provided in OSU Fertilizer Guides 18 and 20.

Management

The timing of the removal of top growth of alfalfa by mowing or grazing has a profound influence on the productivity and length of life of an alfalfa stand. The large taproot of the alfalfa plant is a storage organ for food reserves that are needed to renew top growth in the spring and after each cutting. The maintenance of food reserves is necessary to keep the stand vigorous and productive. The amount of food reserves in alfalfa roots increases as the interval between cuttings is increased to 35 days, after which it declines. Cutting more frequently than 28 days or continuous grazing will lower the root reserve and weaken the stand.

Hay quality

Cutting at the proper stage of growth has a greater influence on hay quality, total production, and life of the stand than any other management decision. The highest quality hay is cut in the early bud stage when the plants have a high proportion of leaves that are rich in protein. As the plants mature, the stems become more coarse and constitute a larger proportion of the total plant, protein percentage decreases, and fiber content increases. However, alfalfa cut at the pre-bud stage produces less forage per acre and continued early cutting seriously weakens the stand.

For first cutting, the bloom is often delayed by cool weather and low light intensity. The appearance of new bud growth at the crown (near the soil surface) or the yellowing of lower leaves is usually a better indicator of time to make the first cutting.

Alfalfa for pasture

Early season grazing of alfalfa provides a method of using the first cutting, which is often damaged by spring rains if made into hay. When pastures are grazed, however, the soil must be dry enough to avoid crown damage from trampling.

If alfalfa is used for year-round pasture, a rotational grazing system must be provided to allow root reserves to be replenished. A rotation that provides 30 to 35 days of regrowth is adequate. If continuously grazed, plants should be kept between 3 and 6 inches high during the spring and summer and allowed to increase to a height of 8 to 12 inches during the fall. This top growth may be removed following a killing frost without reducing winter survival.

Bloat is often a problem for animals on pastured alfalfa. Often, the methods of controlling bloat have been troublesome, expensive, and only partially effective. Using a grass-legume mixture in pastures, supplementing legumes with grass hays, intensive strip grazing with electric fences, and drylot feeding have all been somewhat successful.

The most promising preventative treatment involves the use of bloat-preventative materials. These antifoaming compounds may be added to drinking water, applied as a top dressing on grain supplements, included in pellets, or added to salt-molasses blocks supplied on pasture. However, the effectiveness of these methods is variable and depends upon animals obtaining a regular supply of bloat preventative.

By David B. Hannaway, Extension agronomist, and William S. McGuire, professor of agronomy, Oregon State University.

FS 265
August 1981

Growing Reed Canarygrass for Forage

Area of Adaption

Reed canarygrass *(Phalaris arundinacea)* is adapted to the northern part of the United States and to southern Canada. Large acreages are found in the Pacific Northwest and in the north-central states. Reed canarygrass is tolerant of flooding and poorly drained, wet areas. It is also fairly tolerant of drought but may winterkill in cold, dry climates.

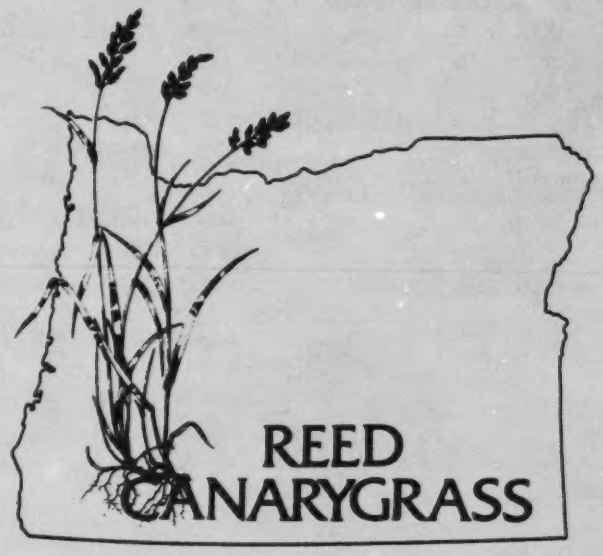
Primary Use

Reed canarygrass can be used for pasture, hay, or silage. It is often used in soil conservation programs and can be used for gully control, on grassed waterways, and on edges of farm ponds. However, it is seldom used in Oregon on better drained land or with irrigation. Species that are more palatable and easier to manage can be used in these situations.

When reed canarygrass is used alone for pasture, satisfactory performance may be obtained with both sheep and cattle. Reed canarygrass is not recommended for use by dairy cows. The addition of white clover in new plantings will improve sheep and cattle performance, but the grass often forces out the clover. High yields (7-8 tons/acre) of hay have been reported in Oregon when reed canarygrass is fertilized adequately. Preservation of reed canarygrass as silage offers the advantage of saving the feed value when conditions are not suitable for making hay.

Varieties

"Common" reed canarygrass is available from a number of suppliers. The cultivar Superior was developed in Oregon for use in upland areas.



Use	Precipitation	Reed canarygrass seeding rate	Companion species	Companion species seeding rate
	Inches	*Lbs/A*		*Lbs/A*
Pasture	> 40 or wetlands	7-8	------	------
		5-6	White clover	2-3
		5-6	Birdsfoot trefoil	4-6
		5-6	Big trefoil	2
Hay or silage	> 40 or wetlands	7-8	------	------

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Several other improved varieties have been developed, including Castor, Ioreed, and Vantage, but no data are available on their performance in Oregon.

Establishment

Much of the available seed has low germination percentages, so reed canarygrass is somewhat difficult to establish. Either spring or late summer seeding is satisfactory if sufficient moisture is available. In areas that are too wet for seeding at these times, a very late seeding is possible for spring germination. Seed should be planted ¼ inch deep in areas where a seedbed can be prepared. Broadcast seeding is also acceptable in areas that are too wet to work. For conservation planting in waterways or for bank erosion control, small pieces of sod can be placed 1 to 2 inches below the soil surface, or they can be distributed on the soil surface and disked in. The entire area should then be broadcast-seeded and firmed with a roller.

Fertility and pH Requirements

Since legumes can be maintained in combination with reed canarygrass only under heavy grazing management, nitrogen fertilization is usually necessary. Forage yields continue to increase with application of more than 200 pounds of nitrogen per acre per year. However, split applications of nitrogen are recommended for a more even distribution of forage production. If reed canarygrass is planted in combination with a legume, nitrogen fertilization will not be required. Early spring application of 30 to 35 pounds of nitrogen will, however, provide for earlier and more vigorous spring growth. Specific recommendations for phosphorus and sulfur, based upon soil test data, are provided in OSU Fertilizer Guides 1 and 58. Although not tolerant of saline soils, reed canarygrass will tolerate pH ranges of 5 to 8.

Management

Rotational grazing, which utilizes heavy grazing pressure for short periods, results in the best utilization of reed canarygrass pastures. Light, continuous grazing results in selective grazing in which mature growth accumulates. If a stiff, short stubble builds up, a single close clipping to a height of 2 to 3 inches will improve utilization.

Highest hay and silage quality will be obtained if the crop is harvested before heading. In this way, two or three excellent quality crops can be obtained. In areas that are too wet to harvest early enough to obtain good quality hay, the mature grass can be harvested for bedding material.

By David B. Hannaway, Extension agronomist, and William S. McGuire, professor of agronomy, Oregon State University.

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Growing Meadow Foxtail for Forage

Area of Adaption

Meadow foxtail *(Alopecurus pratensis)* is native to temperate climates and is widely used in wetland areas for pasture or as a hay crop. In the Pacific Northwest it is most productive in fertile soils of cool, moist areas. Although it is drought resistant, meadow foxtail is not productive under moisture stress or high temperature conditions. Once established, meadow foxtail is very persistent and can become a weed. For this reason, other forage species should be used in seed production areas.

Primary Use

Meadow foxtail is primarily used as a pasture grass. It is a long-lived, early maturing, moderately productive perennial grass and produces over a long grazing season in cool, moist environments. As a pasture grass, it is often seeded with big trefoil or white clover. The addition of these legumes improves the performance of the livestock grazing this forage. This mixed pasture is suitable for either sheep or cattle. Meadow foxtail also makes a palatable hay crop if harvested at an early stage of maturity. Because of its timothy-like seed head, meadow foxtail hay is often sold as scotch timothy for racehorses.

Varieties

No specific varieties have been examined for use in Oregon, as practically all seed is harvested from naturalized stands in Oregon. However, Garrison, an improved stolonaceous variety, has been evaluated in Montana, Wyoming, and Colorado. It was found to be a vigorous creeping meadow foxtail.

Establishment

Meadow foxtail has a light, fluffy seed, so seeding is normally done by broadcast methods. The seed is very difficult to drill unless mixed with rice hulls or other seeds. Either early spring or late fall seeding is acceptable. In areas too wet for preparing a seedbed, seeding should be followed by rolling the soil. Areas previously pre-

Use	Precipitation	Meadow foxtail seeding rate	Companion species	Companion species seeding rate
	Inches	*Lbs/A*		*Lbs/A*
Pasture	> 40 or wet	8	Big trefoil	2
	or flooded	8	White clover	2-3
Hay	> 40 or wet	10	------	------
	or flooded	8	Big trefoil	2

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pared for seeding can be harrowed or rolled to improve soil/seed contact.

Fertility and pH Requirements

If meadow foxtail is planted in combination with a legume, no nitrogen fertilizer is needed for high levels of production. However, application of 40 pounds of nitrogen per acre in early spring will result in more rapid spring growth. When meadow foxtail is used as a hay crop without a legume, nitrogen will be needed for satisfactory production. The use of 100 to 200 pounds nitrogen per acre in split applications is the most efficient practice. Specific fertilizer recommendations based upon soil test data are available in OSU Fertilizer Guides 1 and 58 .

Management

When meadow foxtail is used as a pasture grass, a rotational grazing system is best. Since it is not as palatable as some other grasses, heavy grazing pressure for short periods results in best utilization.

The early maturing characteristic of meadow foxtail can be offset somewhat by early cutting or grazing. If used as a hay crop, meadow foxtail should be cut as early as possible in May, since early cut hay is much higher in quality than more mature late cut hay.

By David B. Hannaway, Extension agronomist, and William S. McGuire, professor of agronomy, Oregon State University.

FS 260
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Growing Kentucky Bluegrass for Forage

Area of Adaption

Kentucky bluegrass *(Poa pratensis)*, is grown extensively in the middle and northwestern sections of the United States, and in parts of Oregon, Washington, and Idaho. It has a wide adaption for soils, but is best suited to well-drained soils of limestone origin. Kentucky bluegrass can be grown in irrigated pastures in central, south-central, and northeastern Oregon. However, because it has lower productivity than other perennial grasses in most areas of the state, it is recommended for use only in the Klamath Falls area of Oregon.

Primary Use

Kentucky bluegrass is used primarily in irrigated pastures in combination with white clover. This combination typically has been associated with horse pastures, but it can be used effectively with beef or sheep as well. Kentucky bluegrass is a long-lived perennial that produces a dense sod from rhizomes. Although Kentucky bluegrass is relatively low in production in midsummer, yields can be increased by adequate irrigation and an ample supple of nutrients. In many cases, however, other grass forage species will be superior to bluegrass for forage production.

Varieties

Kentucky bluegrass is apomictic in nature. That is, seed may be produced without fertilization. For this reason a wide range of variability is present in this grass species. "Common" Kentucky bluegrass is a general-purpose grass for pasture or lawn use. Low-growing types have been selected for turf suitability. Of these, Kenblue, Park, and Troy were selected for reduced management requirements and are suitable for pastures. Superior cultivars have not been developed specifically for pasture or forage purposes. This may explain why greater forage production is often obtained with other forage grasses.

Establishment

Seedings can be made in the spring or late summer in irrigated pasture. Seed should be planted ¼ to ½ inch deep in well-prepared soil that is firm below a depth of 2 inches.

Use	Precipitation	Kentucky bluegrass seeding rate	Companion species	Companion species seeding rate
	Inches	*Lbs/A*		*Lbs/A*
Pasture	Irrigated	5-10	White clover	2-3
		5-10	Birdsfoot trefoil	6

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Fertility and pH Requirements

Kentucky bluegrass requires a high level of fertility for maximum production. It does best on soils of near neutral to alkaline pH (6.5 to 8.0) as long as those soils are not saline or sodic. Adequate liming and fertility should be provided for companion legumes in order to produce a good stand and reduce competition from weeds. Specific recommendations based upon soil test data may be found in OSU Fertilizer Guide 21.

Management

For most productive pastures, Kentucky bluegrass pastures should be kept between 2 and 6 inches. Overgrazing of bluegrass pastures will result in poor root and rhizome development, while undergrazing will result in excess grass competition. Proper grazing management, in addition to providing adequate levels of nutrients and a proper soil pH, will encourage good growth of companion legumes in clover-grass pastures. If clovers disappear from clover-grass pastures, they may be reintroduced by pasture renovation techniques.

If birdsfoot trefoil is used as the legume with Kentucky bluegrass, rotational grazing should be used because trefoil is sensitive to close grazing. A recovery period that allows birdsfoot trefoil to initiate flowering, followed by grazing to a height of 2 to 4 inches, will encourage a long-lived grass-legume pasture.

By David B. Hannaway, Extension agronomist, and William S. McGuire, professor of agronomy, Oregon State University.

FS 266
August 1981

Growing Timothy for Forage

Area of Adaption

Timothy *(Phleum pratense)* is distributed throughout temperate and subarctic climates. It is adapted to cool, humid climates and is sensitive to drought. In Oregon it is best adapted to areas where rainfall is above 20 inches annually.

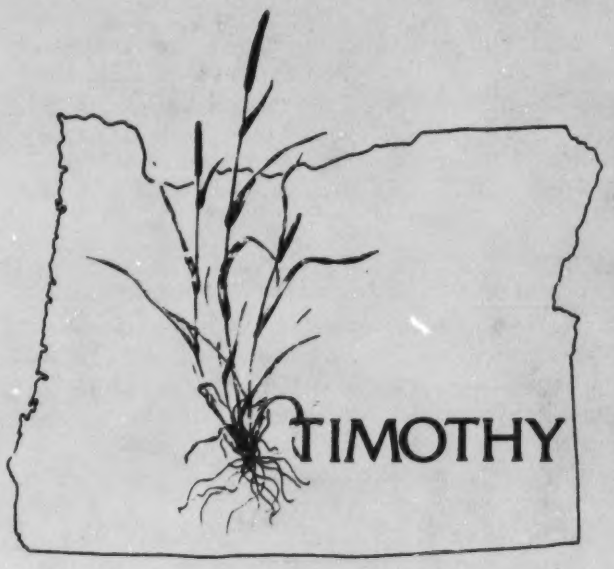
Primary Use

Timothy is grown primarily for hay in Oregon but also can be used in combination with legumes and other grasses as a short-lived perennial grass. It is well suited for use on well-drained, but moist, clay or loam soil. On well-drained soil, alfalfa will do well with timothy, but alfalfa alone will be more productive. Red clover also can be used with timothy, but this mixture has a stand life of only 3 years. In wetter areas, birdsfoot or big trefoil are suitable legumes for use with timothy.

Timothy hay is highly valued as a desirable and palatable horse feed. As with most grasses, it is low in feed value if harvested at a late stage of maturity.

Varieties

Climax is an early maturing variety that has been suggested for use in Oregon for many years. Several other improved varieties have been developed, including Basho, Champ, and Clair.



Establishment

Timothy, when established with a legume, should be planted at the recommended time for planting the legume. If sown alone as a hay crop, timothy can be seeded in early spring or late summer. Spring plantings should allow 4-6 weeks of establishment time before the dry summer period, and an equal amount of time should be allowed before the first freeze is expected for fall plantings.

Use	Precipitation	Timothy seeding rate	Companion species	Companion species seeding rate
	Inches	*Lbs/A*		*Lbs/A*
Hay	40-60	6	-----	-----
		4	Alfalfa	6-8
		4	Red clover	8
		4	Birdsfoot trefoil	6
	> 60 or irrigated	2	Big trefoil	2
		2	Birdsfoot trefoil	6
Wetland pasture	40-60	4	Birdsfoot trefoil	6

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Seed should be planted less than ¾ inch deep in moist soil (about 60 percent of field capacity). Very wet conditions may necessitate surface seeding, while dry conditions will require somewhat deeper planting.

Fertility and pH Requirements

Liming and fertilization should be based on soil tests. A moderately acid to neutral pH range (5.5 to 7.0) is acceptable, but timothy will not tolerate soil salinity. Timothy will do well with only a small amount of starter nitrogen as part of a complete fertilizer. This should be incorporated before planting. The soil should be retested every 2 years and fertilizer applications adjusted accordingly.

Management

In timothy-legume mixtures, timothy uses some of the nitrogen fixed by the legume, and this reduces the need for applied nitrogen fertilizer. Application of fertilizer nitrogen will favor the growth of timothy over that of the legume, resulting in a decrease in the percent legume in the stand. However, an application of 30 to 35 pounds of nitrogen per acre in late February or early March will stimulate the growth of the timothy and provide additional early growth and forage.

If grown alone, timothy requires split nitrogen applications for maximum yield. However, total nitrogen application should not exceed 150 to 200 pounds per acre, because of the potential for lodging at high rates of nitrogen.

Timothy or timothy-legume mixtures should be harvested at an early stage of maturity for highest hay quality. An early cut hay will provide a much higher percent of digestible protein and metabolizable energy than late cut hay. However, greater quantities of dry matter are produced in later harvests. A suitable compromise between quality and quantity is to harvest the timothy shortly after emergence of the seed head from the leaf sheath. In the mid- and late-season varieties, this stage of maturity will occur in late June or early July when the risk of rain is low.

Persistence

Stand life of timothy will be increased by proper fertility and cutting management. Providing adequate nutrients to replace those removed in hay crops is important. In addition, the plant must be allowed to store adequate food reserves (carbohydrates) in its roots and crown area for winter survival. If used for grazing, timothy is very short-lived.

By David B. Hannaway, Extension agronomist, and William S. McGuire, professor of agronomy, Oregon State University.

FS 254
August 1981

Growing Alsike Clover for Forage

Area of Adaption

Alsike clover (*Trifolium hybridum*) is grown in the Pacific Northwest and the Great Lakes region of the upper Midwest. It has become an important forage legume in areas suited to clover-timothy production. Alsike clover is well adapted to wet, heavy soils and is tolerant of flooded conditions. It produces well on soils that are either too cold and wet or too acid or alkaline for red clover.

Primary use

Alsike clover is a short-lived legume (3 years average) that is most useful in short-rotation pastures or in hay mixtures on wetlands. It can be used in combination with grasses for pasture or hay in areas that have high precipitation or are poorly drained.

Varieties

Aurora and Dawn, cultivars developed in western Canada for winter hardiness, are quite suitable for use in Oregon. Tetra is a tetraploid variety developed in Sweden for persistence and high yield. "Common" alsike clover is also available from several suppliers.

Establishment

Alsike clover is most often established in the early spring when soil moisture conditions are most favorable. In areas where irrigation is available, late summer seedings are also successful. Seed may be broadcast and covered by a harrow or drilled ¼ inch deep into a well-prepared seedbed. When alsike is used in renovating pastures, the existing sod should be clipped or closely grazed, disked, fertilized, and seeded in early spring or late fall. As with all legumes, alsike clover should be inoculated with the proper inoculum immediately before seeding.

Fertility and pH Requirements

Alsike clover is tolerant of acid soil but is responsive to lime. It will tolerate more alkalinity

Use	Precipitation	Alsike clover seeding rate	Companion species	Companion species seeding rate
	Inches	*Lbs/A*		*Lbs/A*
Pasture	30-100	4	Reed canarygrass	8
or hay		4	Timothy	6
		4	Perennial ryegrass	10-12
Hay	> 40 or	6	.....	.....
	wetlands	3	Red clover	9

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than most other clovers. An acceptable pH range for alsike is 5.5 to 7.5. Specific fertilizer recommendations based upon soil test data for clover-grass pastures are provided in OSU Fertilizer Guides 1 and 58.

Management

Including timothy with plantings of alsike for a hay crop is recommended because the clover has a tendency to lodge. Alsike clover produces only one crop of hay each season.

Alsike clover is quite tolerant of grazing. A rotational system where alsike is grazed to a height of 2 to 4 inches following a regrowth period of 4 weeks will result in a persistent stand of good-quality forage.

Since alsike is more tolerant than red clover to attacks of clover root borer, it may be successful in areas where red clover has failed.

By David B. Hannaway, Extension agronomist, and William S. McGuire, professor of agronomy, Oregon State University.

rate for small grains should be reduced 50 to 75 percent. If red clover seed is broadcast, it should be covered by using a harrow.

When used in pasture renovation, red clover is best established when the existing sod is closely grazed and disturbed by disking. Seed sown in early spring will result in a good stand of clover in permanent pastures.

Fertilization and pH Requirements

Red clover requires a high level of fertility for greatest production and longevity. In western Oregon, high levels of production can be achieved with a soil pH as low as 5.5, while in other areas of the state pH values between 6.0 and 7.5 are recommended for optimal red clover production. Specific fertility recommendations for red clover based upon soil test data are provided in OSU Fertilizer Guide 17.

Management

If red clover is seeded in the spring with a companion small grain, this crop should be removed as hay or silage to prevent serious competition. In pastures renovated in early spring, two hay crops may be harvested the first year.

During the second year of production, harvest should be made between the prebloom and early bloom stage of maturity for highest forage quality. The regrowth may be made into hay or used as pasture. The second regrowth also may be made into hay, but this may cause lower yields in the third year. However, grazing or cutting following a killing frost will not damage the stand or reduce the next year's crop.

If used for pasture, red clover-grass mixtures should be rotationally grazed to a height of 4 to 6 inches following a 4-week regrowth period.

Oestrogen

Red clover contains a high concentration of oestrogen and can cause infertility in sheep. For this reason, red clover should not be used for sheep pasture during the breeding season.

By David B. Hannaway, Extension agronomist, and William S. McGuire, professor of agronomy, Oregon State University.

FS 255
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Growing Red Clover for Forage

Area of Adaption

Red clover (*Trifolium pratense*) is extensively grown alone or in combination with grasses for hay and pasture in the northeastern, north-central, and southeastern United States. In the Pacific Northwest it is grown under irrigation or in areas with good drainage and soil moisture.

Primary Use

Red clover is a short-lived perennial (2-3 years) that can be used in short-rotation pasture (2-4 years) or as an addition to long-rotation or semipermanent pasture. When used in the longer rotation pastures, red clover contributes to production during the establishment period and is then replaced by other legumes. Red clover also can be used as a hay crop in combination with orchardgrass, timothy, or small grains.

Varieties

Kenland and Pennscott are varieties that have been recommended for many years for use in Oregon. Kenland has good persistence and is resistant to southern anthracnose. Pennscott has a highly vigorous seedling and yields well.

Kenstar is a cultivar that was developed from Kenland. It has a good stand persistence and is resistant to bean yellow mosaic virus and southern anthracnose. Arlington, Altaswede, and Lakeland are also available in certified seed.

Establishment

Early spring seeding of red clover is preferred because the soil moisture conditions are more favorable. However, red clover may be seeded in late summer if moisture conditions are favorable. Broadcast seeding, for spring germination, may be made until the end of January.

When sown as a hay crop, red clover should be broadcast or drilled ¼ inch deep in a well-prepared seedbed. If red clover is sown with small grains for a grain/red clover hay crop, the seeding

Use	Precipitation	Red clover seeding rate	Companion species	Companion species seeding rate
	Inches	*Lbs/A*		*Lbs/A*
Pasture	35-100	6	Perennial ryegrass or orchardgrass and	10-13
			alsike clover or white clover	2-3
Hay	40-60	8	Orchardgrass	10
		8	Timothy	8
		10-12	Small grain	70

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Growing Big Trefoil for Forage

Area of Adaption

Big trefoil (*Lotus pedunculatus, Lotus uliginosus, Lotus major*) is well adapted to poorly drained, acid soils and is more tolerant of wet conditions than birdsfoot trefoil (*Lotus corniculatus*). It will tolerate standing water and flooded areas and can be found growing in drainage ditches that carry water all winter. Big trefoil is grown primarily along the Atlantic and Gulf coasts. In Oregon, it also may be grown in cool, upland areas with high rainfall, but is restricted to use in western Oregon because it lacks the winter hardiness required by conditions in the eastern part of the state.

Primary Use

Big trefoil can be used as a companion legume to reed canarygrass, meadow foxtail, or tall fescue on poorly drained pasture land. Although primarily suited to high rainfall areas, big trefoil can be used in wet, seepy areas where rainfall is less than 40 inches.

Varieties

Marshfield is a relatively new variety and produces well in western Oregon. Columbia and Beaver are older varieties and seed is likely unavailable. "Common" big trefoil is available from some suppliers.

Establishment

A good seedbed is necessary because trefoils have low seedling vigor. Seed should be planted no deeper than ¼ inch after inoculation with the correct bacteria. Big trefoil requires its own specific bacteria and will not become nodulated with cultures used for birdsfoot trefoil or other legumes. Big trefoil should be planted in the spring as soon as a seedbed can be prepared. In areas where it cannot be drilled, big trefoil can be established by surface sowing in March. Late summer plantings are less satisfactory because big trefoil usually is planted in areas with poor winter drainage and the plants may not be well established. For best seedling establishment, broadcast or drill seeding should be followed by using a corrugated roller.

Use	Precipitation	Big trefoil seeding rate	Companion species	Companion species seeding rate
	Inches	*Lbs/A*		*Lbs/A*
Pasture or hay	40-60	2	Tall fescue	15
		2	Meadow foxtail	8
		2	Reed canarygrass*	10

* Reed canarygrass must be kept below 1 foot in height by grazing to prevent it from taking over the big trefoil.

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Fertility and pH Requirements

Big trefoil will tolerate acid soil conditions and low fertility. However, improved production will be obtained by adequate levels of phosphorus (70 lbs/A of P_2O_5).

Management

Big trefoil, a non-bloating legume, is more tolerant of grazing than birdsfoot trefoil because of the presence of rhizomes. It should not be grazed closer than 2 to 4 inches, and a 4-week recovery period should be used to ensure a long-lived stand.

The nutritional value of big trefoil is similar to that of birdsfoot trefoil and alfalfa. However, when grown on nonirrigated or drier sites, big trefoil is less productive than birdsfoot trefoil because of its shallower root system.

By David B. Hannaway, Extension agronomist, and William S. McGuire, professor of agronomy, Oregon State University.

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FG 3

LIMING MATERIALS FOR OREGON

LIME QUALITY

The quality of liming material is related to its degree of fineness or particle size, the chemical composition or calcium carbonate equivalent, and the moisture content.

FINENESS FACTOR (ff)

The ff is related to the particle size of a liming material. *The particle size affects the rate at which a liming material goes into solution in the soil.* Lime does not neutralize acidity or release its nutrients until it has dissolved. Lime particles which are less than 7/100 (7 hundredths) of an inch in diameter (particles of this size will pass through a #10 sieve) are considered to be soluble enough to be effective. Liming material particles which do not pass a #10 sieve are considered to be relatively non-effective. The degree of solubility increases as the particle size decreases from #10 to #40 sieve, with lime particles which pass a #40 sieve being given the maximum solubility rating. Solubility ratings for different particle sizes are given in the table below. Liming materials are given an ff value based on particle size; ff values are calculated as indicated below.

CALCIUM CARBONATE EQUIVALENT (cce)

The cce is an expression of the acid neutralizing value of a liming material compared to pure calcium carbonate. Pure calcium carbonate is given a rating of 100.

Calcium Carbonate Equivalent of Some Liming Compounds

Common name	Chemical name	Chemical formula	cce
Ground limestone	Calcium carbonate	$CaCO_3$	100
Dolomite	Calcium-magnesium carbonate	$CaMg(CO_3)_2$	109
Hydrated lime	Calcium hydroxide	$Ca(OH)_2$	135
Burned lime	Calcium oxide	CaO	179

MOISTURE FACTOR (mf)

As water does not reduce acidity, the acid neutralizing value of a liming material decreases on a weight basis as the moisture content increases.

$$mf = \frac{100 - \%\ \text{water in lime}}{100}$$

A liming material containing 15% water would have a moisture factor,

$$mf = \frac{100-15}{100} = 0.85$$

LIME SCORE (ls)

The ls of a dry liming material is a numerical expression of the quality of the lime and takes ff, cce, and mf into account.

A sample calculation of an ls value is given below.

LIME SCORE SAMPLE CALCULATION

ANALYSIS OF LIMING MATERIAL

Sieve Analysis

Passing #10 sieve	98%
Passing #20 sieve	92%
Passing #40 sieve	78%

Neutralizing value = cce = 92

Moisture content = 15%

CALCULATION OF LIME SCORE

Particle size group	Percent in particle size group (A)	Solubility rating (B)	Fineness value (A) x (B)
No. 40 sieve or smaller (% passing #40 sieve)	78	1.00	78
#20-40 sieve (% passing #20 minus % passing #40 sieve)	14	0.60	8.4
#10-20 sieve (% passing #10 minus % passing #20 sieve)	6	0.30	1.8
#10 sieve or larger (100% minus % passing #10 sieve)	2	0	0
		Total	88.2

$$\text{Fineness factor (ff)} = \frac{\text{Total of fineness values}}{100}$$

$$= \frac{88.2}{100} = 0.88$$

$$\text{Moisture factor (mf)} = \frac{100-\%\ \text{water in lime}}{100}$$

A liming material containing 15% water would have:

$$mf = \frac{100-15}{100} = 0.85$$

1. The annual application of 10-15 lbs S/A in the form of sulfate or as fine ground (finer than 40 mesh) elemental S. Elemental S will not be available to plants until the soil warms up.

2. Applying 30-40 lbs S/A as sulfate or fine ground elemental S every second year.

3. Applying coarser ground elemental S at higher rates and less frequently.

OTHER NUTRIENTS

Responses of fine fescue to nutrients other than those discussed in this guide have not been observed in Oregon.

LIME

Fine fescue has responded to applications of lime in experiments conducted on acid soils in the Willamette Valley.

The application of lime is suggested when the soil pH is below 5.5 or the soil test for calcium (Ca) is below 5 meq Ca/100g. Lime should be worked into the seedbed at least several weeks before seeding. The amount of lime required is based on an SMP lime requirement test.

If the OSU SMP buffer test for lime reads:	Apply this amount of lime (T/A):
Below 5.2	4 - 5
5.2 - 5.5	3 - 4
5.5 - 5.8	2 - 3
5.6 - 6.2	1 - 2
Over 6.2	0

The suggested liming rate is based on 100 score lime. Liming materials should be checked for score.

A lime application is effective over several years.

The use of N fertilizers for grass seed crops will tend to increase soil acidity (decrease soil pH). This should be considered in establishing or renovating perennial grass seed fields.

The surface application of lime to established seed fields could increase the soil pH in the surface one-half inch of soil and thereby increase the possibility of N loss from ammonium N and urea due to volatilization. Also, broadcasting lime on established stands of perennial grasses is not as effective as mixing lime with the soil.

Evaluate the soil acidity problem before making new plantings. The lime application should allow for some decrease in soil pH during the life of a perennial stand of grass.

Some soils may have a fairly high OSU SMP buffer value (over 6.2) and a low pH (below 5.3). This condition can be caused by the application of acidifying fertilizer. In this case the low pH value is temporary and the pH of the soil will increase as the fertilizer completes its reaction with the soil. This temporary "active" acidity from fertilizer is encountered following recent applications of most nitrogen fertilizer materials. Acidifying fertilizers also have a "long term" acidifying effect on soil which is cumulative and leads to lower OSU SMP buffer readings.

Sandy soils to which fertilizers have not been recently applied sometimes record low pH and high SMP buffer values. In such cases, a light application of lime (1 to 2 T/A) should suffice to neutralize soil acidity.

For acid soils low in Mg (less than 0.5 meq Mg/100g of soil) one ton/A of dolomite lime can be used as a Mg source. Dolomite and ground limestone have about the same ability to neutralize soil acidity.

The P, K, and lime recommendations are based on soil test values from the Soil Testing Laboratory, OSU, Corvallis, Oregon.

Prepared by Thomas Doerge, Department of Soil Science; Hugh Gardner and T. L. Jackson, Extension Soil Scientists; and Harold Youngberg, Extension Agronomist; Extension Service and Agricultural Experiment Station, Oregon State University, Corvallis, Oregon.

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FG 5

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ANNUAL RYEGRASS SEED

(Western Oregon—West of Cascades)

Most of the annual ryegrass is produced on Dayton soils (white land) and all of the annual ryegrass fertilizer experiments have been carried out on these soils. The following recommendations are for annual ryegrass grown on Dayton soils.

Good management practices are essential if optimum fertilizer responses are to be realized. These practices include use of recommended varieties, weed control, disease and insect control, good seed bed preparation, proper seeding methods, and timely harvest.

Recommended soil sampling procedures should be followed in order to estimate fertilizer needs. Your county agent can provide you with soil sampling instructions, soil sample bags, and information sheets.

NITROGEN (N)

Liberal amounts of available N are required for optimum yields of annual ryegrass seed.

Fall application

Apply 20 lbs of N/A in the fall at planting time. A light fall application is important to promote seedling vigor. For fields which are pastured, higher rates of fall applied N produce more feed.

Grazing annual ryegrass fields may provide an additional source of income. Sheep grazing at moderate to heavy stocking rates from the start of spring growth (mid-February) through early April has not reduced seed yield. Shorter duration of grazing or lower stocking rates have not increased seed yields.

Spring grazing of annual ryegrass fields will increase the number of seed heads; however, the delayed heading will result in reduced seed bearing capacity per head. Thus the yield components are balanced and seed yield is maintained. There is no effect on germination or seedling vigor.

Spring application

Apply 80 to 100 lbs of N/A between March 1 and April 30. Applications of N can be made through mid-May if soil moisture remains adequate. Do not make spring applications of N until grazing has been completed.

N losses due to leaching, denitrification, and surface water runoff can be reduced by delaying N application until no standing water remains on the field.

PHOSPHORUS (P)

Soil testing should be used to evaluate the need for P fertilization.

Phosphorus should be placed near the seed in the fall at planting time.

If the OSU soil test for P reads (ppm)	Apply this amount P_2O_5 (lb/A)
0 to 15	40-60
15 to 25	30-40
over 25	None

The P content of fertilizer is expressed as the oxide (P_2O_5) on fertilizer labels. Multiply P_2O_5 by 0.44 to convert to P.

POTASSIUM (K)

Soil testing should be used to evaluate the need for K fertilization.

If the OSU soil test for K reads (ppm)	Apply this amount K_2O (lb/A)
0 to 100	60
over 100	None

K should be placed near the seed at planting time or broadcast and worked into the seedbed prior to planting. Not more than 30 to 40 lbs K_2O/A should be placed near the seed.

SULFUR (S)

Include 10-15 lbs/A of S in the annual fertilizer program for annual ryegrass. S is sometimes contained in fertilizers used to supply other nutrients such as N, P, and K but may not be present in sufficient quantity.

Plants absorb S in the form of sulfate. Fertilizer materials supply S in the form of sulfate and elemental S.

Elemental S must convert to sulfate in the soil before the S becomes available to plants. The conversion of elemental S to sulfate is usually rapid for fine ground (less than 40 mesh) material in warm moist soil.

OTHER NUTRIENTS

Responses of blue grass to nutrients other than those discussed in this guide have not been observed in Oregon.

LIME

Blue grass has responded to applications of lime in experiments conducted on acid soil in the Willamette Valley.

The application of lime is suggested when the soil pH is below 5.8 or the soil test for calcium (Ca) is below 5 meq Ca/100g. Lime should be worked into the seedbed at least several weeks before seeding. The amount of lime required is based on an SMP lime requirement test.

If the OSU SMP buffer test for lime reads:	Apply this amount of lime (T/A):
Below 5.5	4 - 5
5.5 - 5.8	3 - 4
5.8 - 6.1	2 - 3
6.1 - 6.5	1 - 2
over 6.5	0

The suggested liming rate is based on 100 score lime. Liming materials should be checked for score.

A lime application is effective over several years.

The use of N fertilizers for grass seed crops will tend to increase soil acidity (decrease soil pH). This should be considered in establishing or renovating perennial grass seed fields.

The surface application of lime to established seed fields could increase the soil pH in the surface one-half inch of soil and thereby increase the possibility of N loss from ammonium N and urea due to volatilization. Also, broadcasting lime on established stands of perennial grasses is not as effective as mixing lime with the soil.

Evaluate the soil acidity problem before making new plantings. The lime application should allow for some decrease in soil pH during the life of a perennial stand of grass.

Some soils may have a fairly high OSU SMP buffer value (over 6.2) and a low pH (below 5.3). This condition can be caused by the application of acidifying fertilizer. In this case the low pH value is temporary and the pH of the soil will increase as the fertilizer completes its reaction with the soil. This temporary "active" acidity from fertilizer is encountered following recent applications of most nitrogen fertilizer materials. Acidifying fertilizers also have a "long term" acidifying effect on soil which is cumulative and leads to lower OSU SMP buffer readings.

Sandy soils to which fertilizers have not been recently applied sometimes record low pH and high SMP buffer values. In such cases, a light application of lime (1 to 2 T/A) should suffice to neutralize soil acidity.

For acid soils low in Mg (less than 0.5 meq Mg/100g of soil) one ton/A of dolomite lime can be used as a Mg source. Dolomite and ground limestone have about the same ability to neutralize soil acidity.

The P, K, and lime recommendations are based on soil test values from the Soil Testing Laboratory, OSU, Corvallis, Oregon.

Prepared by Thomas Doerge, Department of Soil Science; Hugh Gardner and T. L. Jackson, Extension Soil Scientists; and Harold Youngberg, Extension Agronomist; Extension Service and Agricultural Experiment Station, Oregon State University, Corvallis, Oregon.

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Blue Grass Seed

(Western Oregon—West of Cascades)

Good management practices are essential if optimum fertilizer responses are to be realized. These practices include use of recommended varieties, selection of adapted soils, weed control, disease and insect control, good seed bed preparation, proper seeding methods, and timely harvest.

Recommended soil sampling procedures should be followed in order to estimate fertilizer needs. The Oregon State University Extension Service agent in your county can provide you with soil sampling instructions, soil sample bags, and information sheets.

NITROGEN (N)

Liberal amounts of available N are required for optimum yields of blue grass seed.

On new seedings, place 20-40 lbs N/A near the seed. At least 1 inch of soil should separate the seed and fertilizer.

On established stands, a total annual application of 100 to 120 lbs N/A is suggested.

Apply 20 to 30 lbs N/A in the fall. An adequate supply of N in the fall stimulates early tiller development important to optimum seed production. Apply 70 to 100 lbs N/A during March.

The application of nitrate N to wet soils can result in the loss of N through reduction of nitrate.

PHOSPHORUS (P)

Soil testing should be used to evaluate the need for P fertilization.

On new seedings, when the OSU soil test for P is below 30 ppm, place 30 lbs P_2O_5/A near the seed. At least 1 inch of soil should separate the seed and fertilizer. The application rate should be increased by 50% when P is broadcast rather than placed near the seed.

On established stands, *P should be broadcast in the fall.*

If the OSU soil test for P reads (ppm)	Apply this amount of phosphorus (P_2O_5)-lbs/A
0 to 15	40 - 60
15 to 25	30 - 40
Over 25	None

POTASSIUM (K)

Soil testing should be used to evaluate the need for K fertilization.

On new seedings, when the OSU soil test for K is below 100 ppm, place 25 lbs K_2O/A near the seed. At least 1 inch of soil should separate the seed and fertilizer. The K application rate should be increased by 50% where K is broadcast.

On established stands, *K should be broadcast in the fall.*

If the OSU soil test for K reads (ppm):	Apply this amount of potash (K_2O)-(lbs/A)
0 to 100	60
Over 100	None

SULFUR (S)

Include 10-15 lbs/A of S in the annual fertilizer program for blue grass. S is sometimes contained in fertilizers used to supply other nutrients such as N, P, and K, but may not be present in sufficient quantity.

Plants absorb S in the form of sulfate. Fertilizer materials supply S in the form of sulfate and elemental S.

Elemental S must convert to sulfate in the soil before the S becomes available to plants. The conversion of elemental S to sulfate is usually rapid for fine ground (less than 40 mesh) material in warm moist soil.

S in the sulfate form can be applied at planting time. Some S fertilizer materials such as elemental S and ammonium sulfate have an acidifying effect on soil.

The S requirements of blue grass can be provided by:

1. The annual application of 10-15 lbs S/A in the form of sulfate or as fine ground (finer than 40 mesh) elemental S. Elemental S will not be available to plants until the soil warms up.
2. Applying 30-40 lbs S/A as sulfate or fine ground elemental S every second year.
3. Applying coarser ground elemental S at higher rates and less frequently.

S in the sulfate form can be applied at planting time. Some S fertilizer materials such as elemental S and ammonium sulfate have an acidifying effect on soil.

The S requirements of annual ryegrass can be provided by:

1. The application of 10-15 lb/A (15-20 kg/ha) of S in the form of sulfate at planting time.
2. Applying 30-40 lb/A (35-45 kg/ha) of S as fine ground elemental S the preceding year.
3. Applying coarser ground elemental S at higher rates and less frequently.

OTHER NUTRIENTS

Responses of annual ryegrass to nutrients other than those discussed in this guide have not been observed in Oregon.

LIME

The application of lime is suggested when the soil pH is below 5.5. Lime should be worked into the soil at least several weeks before seeding. The amount of lime required is based on an SMP lime requirement test.

If the OSU SMP Buffer test for lime reads:	Apply this amount of lime (T/A)
below 5.2	4-5
5.2-5.5	3-4
5.5-5.8	2-3
5.8-6.2	1-2
over 6.2	0

The suggested liming rate is based on dry 100 score lime. Liming materials should be checked for moisture content and score.

A lime application is effective over several years.

The surface application of lime where minimum tillage is practiced could increase the soil pH in the surface one-half inch of soil and thereby increase the possibility of N loss from ammonium N and urea due to volatilization. Broadcasting lime is not as effective as mixing lime with the soil.

The use of N fertilizers for grass seed crops will tend to increase soil acidity (decrease soil pH). This should be considered in minimum tillage management of annual ryegrass.

Evaluate the soil acidity problem when renovating or making new plantings. The lime application should allow for some decrease in soil pH during the minimum tillage period.

Some soils may have a fairly high OSU SMP buffer value (over 6.2) and a low pH (below 5.3). This condition can be caused by the application of acidifying fertilizer. In this case the low pH value is temporary and the pH of the soil will increase as the fertilizer completes its reaction with the soil. This temporary "active" acidity from fertilizer is encountered following recent applications of most nitrogen fertilizer materials. Acidifying fertilizers also have a "long term" acidifying effect on soil which is cumulative and leads to lower OSU SMP buffer readings.

For acid soils low in Mg (less than 0.5 meq Mg/100g of soil) one ton/A of dolomite lime can be used as a Mg source. Dolomite and ground limestone have about the same ability to neutralize soil acidity.

P, K, and lime recommendations are based on soil test values from the Soil Testing Laboratory, OSU, Corvallis, Oregon.

These recommendations are based on experiments conducted by Harold Youngberg and William C. Young III, Crop Science Department, Oregon State University, and T. L. Jackson, Oregon Agricultural Experiment Station, and observations of growers' results.

Prepared by E. Hugh Gardner and T. A. Doerge, Soil Science Department; and Harold Youngberg, Crop Science Department, Oregon State University, Corvallis, Oregon. Reviewed by a committee of Western Oregon Extension agents.

Fertilizer Guide

FG 6
Revised March 1982

FINE FESCUE SEED

(Western Oregon—West of Cascades)

Good management practices are essential if optimum fertilizer responses are to be realized. These practices include use of recommended varieties, selection of adapted soils, weed control, disease and insect control, good seed bed preparation, proper seeding methods, and timely harvest.

Recommended soil sampling procedures should be followed in order to estimate fertilizer needs. The Oregon State University Extension Service agent in your county can provide you with soil sampling instructions, soil sample bags, and information sheets.

NITROGEN (N)

Liberal amounts of available N are required for optimum yields of fine fescue seed.

On new seedings, place 20-40 lbs N/A near the seed. At least 1 inch of soil should separate the seed and fertilizer.

On established stands, a total annual application of about 120 lbs N/A is suggested.

Apply 20 to 30 lbs N/A in the fall. Make one or two applications totalling 100 lbs N/A during March or April.

Higher rates of fall applied N can be used where fields are grazed during the winter months.

The application of nitrate N to wet soils can result in the loss of N through reduction of nitrate.

PHOSPHORUS (P)

Soil testing should be used to evaluate the need for P fertilization.

On new seedings, when the OSU soil test for P is below 30 ppm, place 30 lbs P_2O_5/A near the seed. At least 1 inch of soil should separate the seed and fertilizer. The application rate should be increased by 50% when P is broadcast rather than placed near the seed.

On established stands, *P should be broadcast in the fall.*

If the OSU soil test for P reads (ppm):	Apply this amount of phosphorus (P_2O_5)-lbs/A
0 to 15	40 - 60
15 to 25	30 - 40
Over 25	None

POTASSIUM (K)

Soil testing should be used to evalute the need for K fertilization.

On new seedings, when the OSU soil test for K is below 100 ppm, place 25 lbs K_2O near the seed. At least 1 inch of soil should separate the seed and fertilizer. The K application rate should be increased by 50% where K is broadcast.

On established stands, *K should be broadcast in the fall.*

If the OSU soil test for K reads (ppm):	Apply this amount of potash (K_2O)-(lbs/A)
0 to 100	60
Over 100	None

SULFUR (S)

Include 10-15 lbs/A of S in the annual fertilizer program for fine fescue. S is sometimes contained in fertilizers used to supply other nutrients such as N, P, and K, but may not be present in sufficient quantity.

Plants absorb S in the form of sulfate. Fertilizer materials supply S in the form of sulfate and elemental S.

Elemental S must convert to sulfate in the soil before the S becomes available to plants. The conversion of elemental S to sulfate is usually rapid for fine ground (less than 40 mesh) material in warm moist soil.

S in the sulfate form can be applied at planting time. Some S fertilizer materials such as elemental S and ammonium sulfate have an acidifying effect on soil.

The S requirements of fine fescue can be provided by:

OREGON STATE UNIVERSITY EXTENSION SERVICE

Extension Service, Oregon State University, Henry A. Wadsworth, director. Produced and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. Extension work is a cooperative program of Oregon State University, the U. S. Department of Agriculture, and Oregon counties. Extension invites participation in its programs and offers them equally to all people.

Therefore, for this liming material:

Fineness factor (ff) = 0.88
Calcium carbonate equivalent (cce) = 92
Moisture factor (mf) = 0.85

Lime score = ff x cce x mf
= 0.88 x 92 x 0.88
= 69

AMOUNT OF LIMING MATERIAL TO APPLY

Liming recommendations are based on 100-score liming material. The amount of liming material to apply should be calculated as follows:

$$\frac{\text{Recommended liming rate}}{\text{Lime score (ls)}} \times 100$$

As an example, if a liming material had a ls of 69 and the recommended liming rate was 3 T/A, then:

The rate of application of liming material =

$$\frac{3 \text{ T/A}}{69} \times 100 = 4.3 \text{ T/A}$$

Liming recommendations are based on soil test results and vary with the soil and crop to be grown.

A one ton/acre application of 100-score ground limestone supplies about 2 milliequivalents of calcium/100 grams of soil to the surface 6" of a mineral soil.

CHEMICAL COMPOSITION OF LIMING MATERIALS

Liming materials vary in chemical composition. The chemical makeup of lime has an effect on its neutralizing value and nutrient content. Ground limestone, for instance, consists of calcium carbonate and is a source of calcium. Dolomitic limestone consists of calcium carbonate and magnesium carbonate and is a source of both calcium and magnesium. Some liming materials may contain other plant nutrients.

KINDS OF LIMING MATERIALS

Several different kinds of liming materials are available in Oregon. These include:

GROUND LIMESTONE

Consists of calcium carbonate and varying amounts of impurities. This material sometimes contains small amounts of magnesium carbonate. Pure calcium carbonate (calcite) contains 40% Ca.

DOLOMITIC LIME

Consists of varying proportions of calcium carbonate and magnesium carbonate and varying amounts of impurities. The calcium carbonate content can vary from 5% to 55%, the magnesium carbonate content from 33% to 52%, and the magnesium content from 9% to 15%.

Dolomitic lime is commonly recommended as a liming material for acid soils which are deficient in magnesium.

HYDRATED LIME

Sometimes referred to as slaked lime or builder lime. Consists of calcium hydroxide with varying amounts of impurities. It is a white powder which reacts quickly when mixed with moist soil.

BURNED LIME

Sometimes referred to as quick lime or unslaked lime. It consists of calcium oxide and often impurities. It is a white, caustic powder which reacts quickly when mixed with moist soil. Thorough mixing with the soil is important in order to prevent the formation of granules which may harden and be unavailable.

BY-PRODUCT LIMING MATERIALS

Effective liming materials are produced as by-products of industrial processes such as the manufacture of cement, pulp, sugar, calcium carbide, etc. These by-products contain varying amounts of calcium and magnesium compounds and other materials. Some of the names used for these by-product materials are--sugar lime, Cotrell lime or dust, lime sludge, carbide lime and pulp mill lime.

Prepared by E. Hugh Gardner, Extension Soil Scientist, Department of Soil Science, Oregon State University, Corvallis, Oregon.

Reviewed by a committee from the Oregon County Extension Agents and Agricultural Experiment Station and the lime industry.

Alfalfa Production Instructional Materials

Ag II - XI - 75

GROWING ALFALFA IN WESTERN OREGON

Extension Circular 806

Reprinted October 1974

Extension Service

Oregon State University

Corvallis

640

Alfalfa is the most important forage legume in Oregon. When properly harvested, western Oregon alfalfa finds ready markets for local livestock use. It produces large yields of high-quality forage and has a long life when grown under conditions to which it is adapted. Alfalfa grows well on deep, well-drained soils with adequate natural moisture. It responds favorably to irrigation. Its forage is an excellent source of protein, minerals, and vitamins for all classes of livestock and can be utilized as hay, silage, or pasture.

Plant Description

Alfalfa, *Medicago sativa* and *Medicago media*, is a hardy, deep-rooted perennial. Rhizobia, members of a group of bacteria which grow in nodules on the alfalfa roots, are able to fix atmospheric nitrogen in a form available for plant use. This process may make available 200 pounds or more of nitrogen per acre each year for plant growth. The large single taproot may reach a depth of 25 feet in well-drained soil. Alfalfa is thus able to withstand periods of drought by utilization of subsoil moisture. Numerous erect stems arise from buds on the woody crown when older growth is removed by harvesting or as it matures.

Varieties

A large number of alfalfa varieties are available in commercial seed channels. Most alfalfa varieties grown in Oregon belong to two groups:

1. *Variegated*. These alfalfa are generally quite tolerant and produce long-lived stands. Grimm, Ranger, Ladak, Vernal, Atlantic, and Narragansett have been the most popular varieties of this group in Oregon. This group represents the majority of the Oregon alfalfa acreage outside the Willamette Valley.
2. *Flemish*. Most of the recent Oregon plantings have been of the Flemish type. Varieties of this group have been developed from Western European stock. They are noted for early spring growth and quick recovery after cutting which well suit them to the seasonal rainfall patterns. They are sufficiently winter hardy for western Oregon conditions. Alfa, Apex, Cardinal, DuPuits, Flandria, Pat 30, Resistador, and Thor are varieties typical of this group which is suited for Willamette Valley conditions. New varieties are becoming available each year.

   Bacterial wilt has been identified in western Oregon. Resistant varieties should be used where this disease is present.

Certification of Varietal Purity

Once a specific variety with the desired characteristics has been chosen, the best assurance of varietal purity is to buy certified seed. The certified tag is issued only to seed that has passed rigid field standards designed to protect genetic purity and also has met minimum standards of seed purity and germination after processing.

This circular was prepared by Norman Goetze and Harold Youngberg, Extension Crops Specialists, Oregon State University.

Seedling Establishment

Alfalfa requires a deep, permeable soil with an adequate moisture supply during the growing season for maximum yields. It is *very* sensitive to poor drainage and compacted soil conditions which restrict root growth. Thus, alfalfa is most productive on loam or loamy soils that are both well drained and have good moisture-holding capacity. Alfalfa does not tolerate acid soils, especially in the seedling stage. Lime applications well in advance of seeding are required on soils having a pH below 6.0.

Seedbed Preparation

A good seedbed for alfalfa is finely pulverized, leveled, and firmed to the seedling depth with soil moisture near the surface to initiate germination.

Leveling the field to eliminate dead furrows and low spots will result in a more uniform stand and ease equipment travel for the life of the stand.

Methods used to obtain the desired seedbed will vary with soil type and preceding crop. Fall plowing to prepare for spring planting is used where erosion is not a problem. This reduces winter weed growth and permits ample time for spring seedbed preparation. Lime can be spread in the fall and incorporated. This allows time for soil reaction to take place and avoids delays in the spring.

Fertilization

A productive alfalfa crop is a heavy user of plant nutrients. A complete fertilizer program is essential to a long-lived stand. A soil test is the first step in planning a fertility program. Applications of fertilizer and lime should be based on the results of a soil test.

Phosphorus can be applied most effectively by banding 1/2 to 1 inch to the side or below the seed when seeding or by shallow incorporation just prior to seeding.

Potassium, sulfur, and boron should be worked into the seedbed just prior to the seeding operation. Potassium and boron should *not* be banded near the seed.

Lime should be applied and thoroughly mixed with the surface 6 inches of soil. Fall applications provide time for soil reaction to take place and avoid the spring rush which will often delay planting.

Time of Seeding

The proper time of seeding alfalfa is determined by seasonal temperature and moisture conditions. Most Willamette Valley seedings are made during May or early June (April in southwestern Oregon) in time to allow good root systems to form before high temperature and low moisture conditions slow growth rates.

Late summer and fall seedings must be made early and have sufficient soil moisture to allow for enough growth to minimize loss of stand from winter injury. Fall seedings without irrigation to assure establishment by September 15 risk being winter-killed.

Inoculation

The presence of effective nodules on the roots of the plants is *essential* to a vigorous, productive stand. These nodules are formed by bacteria known as *Rhizobium meliloti* that are able to fix nitrogen from the air for use by the alfalfa plants. These bacteria may be present in fields

that have grown alfalfa recently, but all strains of bacteria are not equally effective. All alfalfa seed should be inoculated with a fresh commercial inoculum *immediately prior* to seeding, regardless of cropping history of the land or any previous inoculation of the seed. Inoculated seed should be kept cool and moist until being seeded.

Rate of Seeding

Twelve pounds of seed per acre is sufficient for a good stand of alfalfa. Higher seeding rates are sometimes used to compensate for poor soil preparation or seeding methods. A seeding rate of 12 pounds per acre planted in 6-inch rows will provide 30 seeds per linear foot of drill row or 60 seeds per square foot if broadcast seeded. This is more than adequate to establish a good stand.

Depth of Seeding

Alfalfa seed must be placed in contact with moist soil. Seedlings are unable to emerge from the soil if planted too deep. For best seedling survival, seeds should be drilled approximately 1/4 inch deep. Seedlings will not emerge from depth greater than 1/2 inch.

Grain drills equipped with legume-seeding attachments and band fertilizer placement can be set for proper seed placement and provide for banding fertilizer near the seed. Seeding should be followed by cultipacking to firm the soil and place the seed in intimate soil contact. Severe surface compaction that might cause soil crusting after rains or an irrigation should be avoided.

Use of a Companion Crop

Alfalfa seedlings are poor competitors and require favorable conditions for survival and establishment. A companion crop should not be used except in areas where wind erosion is a problem. The nurse crop will tend to shade out the alfalfa and compete with it for moisture.

Alfalfa-Grass Mixtures

Alfalfa for hay production is usually seeded alone. The decision to seed grass with alfalfa for forage use must be made on an individual basis. There are several advantages in seeding an adapted grass with alfalfa:

- An alfalfa-grass mixture may produce higher quality silage than alfalfa alone.
- A vigorous alfalfa-grass mixture may discourage encroachment of weedy grasses as the stand ages.
- Alfalfa-grass mixtures may be less likely to cause bloat in livestock grazing the stand.

Disadvantages of planting grass with alfalfa include:

- Grass seedlings compete severely with alfalfa seedlings for moisture, nutrients, and light.
- The presence of grass in the hay may lower its marketability.

Alfalfa-grass mixtures in western Oregon will tend to yield more on the first and second cuttings than alfalfa grown alone, while producing less later in the season. This seasonal shift in production may be advantageous when the early cuts can be harvested as silage.

Weed Control During Establishment

Selective herbicides can be used on alfalfa seedings in pre-emergence or post-emergence applications for control of annual weeds. EPTC or benefin can be incorporated during seedbed preparation to control perennial grasses or in fields where grassy weeds are likely to be problems. It should not be used when an alfalfa-grass mixture is to be seeded.

Annual broadleaf weeds can be controlled selectively with 2,4-DB or dinitro amine applied after alfalfa has two or more true leaves and before the weeds have three true leaves. To obtain the current recommendations and forage tolerances of herbicides, consult your county extension agent or the most recent edition of the *Oregon Weed Control Handbook*.

Annual weed competition is often controlled during the seedling year by clipping.

Management of an Established Stand

Fertilization

The fertility requirements of a productive alfalfa stand are quite high because large quantities of nutrients are removed with the crop. The fertility status of the soils must be considered in planning a fertilizer program; thus, all applications should be based on a soil test. Where soil tests indicate moderate or low soil fertility levels, annual fertilizer applications are the key to a productive stand with a long life.

Experiments have shown that alfalfa will economically respond to applications of phosphorus, potassium, sulfur, boron, and lime. The need for these elements will vary with the soil and cropping history. The need for nutrients other than sulfur can be determined with a soil test.

Timing of application, rates, and specific information for western Oregon conditions is given in OSU Fertilizer Guide #18.

Weed Control

Certain weedy annual grasses and broadleaves can be selectively controlled with diuron (Karmex), simazine (Princep), propham (IPC), or chlorpropham (CIPC) without serious crop injury if applied when the alfalfa is dormant. Annual broadleaf weeds can be controlled with 2,4-DB or dinitro amine by application before the weeds have more than three true leaves. Since local conditions influence the safety and time of application of these herbicides, consult local authorities or the Oregon Weed Control Handbook.

Cultivation with a springtooth or harrow has been used in the past to control annual weeds in alfalfa. This practice, however, injures alfalfa crowns, opening them to attack by disease organisms, and weakens the stand. It is *not* recommended.

Maintaining Plant Vigor

The timing of the removal of top growth of alfalfa by mowing or grazing may have a profound influence on the productivity and length of life of an alfalfa stand. The large taproot of the alfalfa plant is a storage organ for food reserves needed to renew top growth in the spring and

after each cutting. The maintenance of food reserves is necessary to keep the stand vigorous and productive. Food reserves in alfalfa roots have been shown to increase as the interval between cuttings is increased to 35 days, after which it declines. Cutting more frequently than 28 days or continuous grazing will lower the root reserve and weaken the stand.

Making Alfalfa Hay

Most of the alfalfa grown in western Oregon is harvested as hay. The procedures used vary with the locality and the season; however, several general principles apply.

Timing of Cutting

Cutting at the proper stage of growth can have a greater influence on hay quality, total production, and life of the stand than any other management decision. The highest quality hay is that cut in the early bud stage when the plants have a high proportion of leaves that are rich in protein. As the plants mature, the stems become coarser and constitute a larger proportion of the total plant. As the plant matures, protein percentage decreases and fiber content increases. However, alfalfa cut at the pre-bud stage produces less forage per acre and continued early cutting seriously weakens the stand.

The bloom is often delayed by cool weather in the spring in western Oregon and is not the best indication of cutting time. The appearance of new bud growth at the crown, near the soil surface, or the yellowing of lower leaves, is the indication of time to make the first cutting. This stage of growth is most often reached in early May. Later cuttings may be made at the late bud or early bloom stage of growth.

Curing

New mown hay contains 70 to 80 percent moisture, depending upon atmospheric conditions. Well-cured hay contains 15 to 20 percent moisture. The objective of the curing step is to provide conditions for the removal of this moisture as rapidly as possible while preserving the green color and preventing leaf shatter. Overdrying with associated leaf loss during handling is one of the more common causes of loss in hay quality. Raking should be done before the leaves dry or during periods of high humidity such as the night or early morning to reduce leaf loss.

Mechanical devices which crush or crimp the alfalfa stem may be helpful in speeding the curing process, thus reducing the time that the hay is exposed to the risk of rain. This is particularly important for the first cutting under western Oregon conditions.

Pasturing Alfalfa

Early season grazing often provides a method of utilizing early alfalfa growth that could not be successively made into hay because of frequent rains. The soil must be dry enough to avoid damage to the stand from trampling.

Continuous close grazing will damage the stand and result in thinning or winter kill. If alfalfa is to be used primarily for pasture, a system of rotational grazing must be provided which allows for a regrowth period of 30 to 3[illegible] days to allow for re-establishment of root reserves. If continuous grazing is allowed, the grazing intensity must be adjusted to allow a plant height of three to six inches and the plants must never be completely defoliated. In the fall, the growth must be allowed to reach 8 to 12 inches and remain until the tops are frozen back.

Grazing may be a profitable way of utilizing regrowth following the last alfalfa cutting of the season. Regrowth must be allowed to build root reserves to reduce winter injury; however, this top growth may be removed after the first killing frost without affecting root reserves.

Bloat

When alfalfa is grazed, caution must always be exercised to prevent livestock losses to bloat. Hungry cattle should never be turned on new alfalfa growth. Feeding grass hay or straw before turning livestock on alfalfa may be of value in reducing excessive intake. Allowing stock to graze only a short time each day until they become accustomed to alfalfa pasture is also recommended. Bloat preventative materials are available which can be fed as a feed additive or in salt blocks.

Alfalfa for Silage

Alfalfa preserved as silage makes excellent feed and avoids many of the harvest problems associated with field curing of hay. Best results are obtained when the alfalfa is cut at the same growth stage as for hay and wilted to 60 to 68 percent moisture before placing in the silo. Thirty to 80 pounds of molasses or 75 to 250 pounds of ground grain to each ton of green alfalfa will provide sufficient carbohydrate to assure proper fermentation to preserve the silage. More information is available in PNW Bulletin No. 14, "Making and Feeding Grass and Legume Silage," available at your county agricultural extension office.

Rodent Control

Gopher, mole, and field mice populations build up in perennial stands of alfalfa because of ample feed supplies and protection of nesting sites. Left uncontrolled, these rodents will lower alfalfa productivity and shorten the life of the stand.

Prevention of population invasions during the seedling year is most desirable. Relative effectiveness of trapping, baiting, and poisoning varies with location and skill of the operator. Detailed recommendations for control of these rodents are given in Extension Bulletin 804, "Mole and Gopher Control."

Encouragement of the natural predators—owls, hawks, fox, and skunks—will also be helpful.

OREGON STATE UNIVERSITY EXTENSION SERVICE

Extension Service, Oregon State University, Corvallis, Joseph R. Cox, director. This publication was produced and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. Extension work is a cooperative program of Oregon State University, the U. S. Department of Agriculture, and Oregon counties.

Verticillium Wilt of Alfalfa

Paul Koepsell, Extension plant pathologist, and
Luther Fitch, Extension agent, Umatilla County

About 3 years ago Verticillium wilt of alfalfa was discovered in the Columbia Basin in Oregon and Washington. This was the first report of this fungus disease in the United States, although it is a major problem in Europe and had been reported in one area of Canada. Verticillium wilt may make alfalfa stands unproductive as early as the second cutting year, but usually becomes severe the third cutting year. Since no efforts were made to breed resistance into our alfalfa, all domestic varieties are susceptible. Investigations since the discovery of this disease in the Pacific Northwest indicate that the causal organism, *Verticillium albo-atrum*, probably has been present in Oregon and other areas of the Pacific Northwest for many years.

Although the pathogen is fairly widespread in Oregon, there are marked differences in incidence and severity of the disease from one geographic location to another. The most severely affected area is in the Columbia Basin, around Hermiston, where some fields decline so rapidly that they are uneconomic after the second harvest year. Most of these fields are on sandy soil under sprinkler irrigation—either wheel line or circle irrigation systems. In the Butter Creek area, where the soil is heavier and generally is flood irrigated only once or twice per year, alfalfa stands have been less affected by Verticillium wilt.

In Malheur County, the wilt occurs in about 5 percent of the fields, but rapid death and severe thinning of the stands are not prominent in this area. Nevertheless, some fields have been affected severely.

In western Oregon, the disease occurs in only a few fields scattered over an area from Woodburn to Roseburg and on most soil types in the area.

A fairly intensive survey failed to detect the disease in the Klamath Falls area, and no specimens have been collected from Klamath Falls since that time. Central Oregon, the Medford area, and the remainder of eastern Oregon have not been surveyed for the disease. Because the disease has not yet been found by Extension agents in these areas, we assume the disease is not present.

The alfalfa Verticillium wilt pathogen

The Verticillium wilt organism that attacks alfalfa is *Verticillium albo-atrum*. Strains of this fungus that attack other crops have been in Oregon for years, but no strains causing alfalfa wilt were detected until recently. Verticillium wilt of mint and potatoes is caused by another species of *Verticillium*, *V. dahliae*. Although these two fungi are similar in many ways, they differ in several important characteristics that affect control methods.

The alfalfa pathogen grows and causes plant disease at a relatively low temperature. The Pacific Northwest, where the pathogen causes the most severe problem, is on the edge of its ecological niche. Generally mid-summer temperatures in this region exceed the maximum for rapid fungus development. Possibly sprinkler irrigation has created a micro-climate that allows disease development. *Verticillium dahliae*, on the other hand, is more tolerant of high temperatures and consequently is better adapted to the Northwest's relatively high summer temperature.

The alfalfa pathogen (*V. albo-atrum*) forms a resting structure that consists of thickened special mycelium (threadlike fungus growth). These resting structures survive in soil for only 3 or 4 years if no susceptible crops or susceptible weeds are present.

Verticillium dahliae forms special resting structures (micro-sclerotia) that survive in soil for up to 10 years without the presence of host plants. Because of these differences in resting bodies, crop rotation may be more effective in controlling alfalfa wilt than it has been for Verticillium wilts of other Oregon crops.

Oregon State University Extension Service

Extension Circular 1002 February 1980

Symptoms of the disease

The first symptom of alfalfa wilt is death of leaves and stems on portions of plants or on entire plants. Unlike plants with bacterial wilt, the plants generally are not dramatically stunted and yellowed. Maximum visual expression of the disease occurs as the plants are nearing harvest. Rapid yellowing occurs, followed by browning of the leaves on erect central stems. Development of the pathogen within the plant is progressive, and eventually the entire plant will die. It is not uncommon for a crown to have several apparently healthy stems while other stems on the crown are dead or dying. Dead or wilted leaves may occur on only one side of the stem. This unilateral wilting, characteristic of many wilt diseases, may occur on individual leaflets. One sector of the leaflet turns yellow and dies, while the remainder dies later as the fungus spreads to the vascular system feeding that part of the leaf. When stems of the infected plants are cut, a brownish-red discoloration may appear in the central portion of the root. This discoloration is not necessarily present in all Verticillium-infected alfalfa plants, and death may occur when no discoloration is present. The discoloration caused by bacterial wilt of alfalfa is less red, and it occurs immediately beneath the bark, not in the central core of the root. Because it is difficult to differentiate between these two diseases on the basis of field symptoms, laboratory analysis (culturing infected tissue on media to isolate the causal organism) usually is necessary for positive diagnosis.

Under European conditions *Verticillium albo-atrum* produces a white growth at the base of infected stems in the field. In the Columbia Basin, sporulation of this fungus has been observed on stems near the center of circle irrigation systems. Spores of this organism probably are more prevalent than observation indicates, as shown by the patterns of spread in the infected fields.

Methods of long-distance spread

The alfalfa Verticillium can move from an infected area to a noninfected area by seed transmission. The fungus is not within the seed but often is in small pieces of leaf, stem, pod tissue associated with the seed, or on the seed surface. Furthermore, any movement of the infected alfalfa as loose, baled, or cubed hay will spread the disease. The passage of infected alfalfa through an animal does not inactivate the fungus, so animals that have eaten the infected hay also spread the disease.

Spread within an infected field

Once in a field, the fungus can spread rapidly. Any cultural operation that moves soil or infected hay will spread the disease. For example, operations such as plowing, cultivating, or moving contaminated equipment will spread the disease. Mowing equipment rapidly spreads spores of the pathogen from one cut surface to another. The spore-contaminated alfalfa sap remains on the cutting bar and spreads in the direction of the cutting. Spread is most rapid when the hay is damp with dew, and can be reduced by cutting only when hay is completely dry.

Water can carry infested soil or plant debris and spores of the fungus. Furrow irrigation or sprinkler runoff from infected fields may contain the Verticillium organism. Workers in Europe have demonstrated that the fungus can move from one crown to an adjacent crown by root grafts. This method of spread is relatively slow and has little practical significance.

Limiting spread within infected field

Once Verticillium is widespread in a field, little can be done to contain the disease. If only small areas of the field are infected, however, there are several ways to limit the rate of spread. Spread of spores by the cutting equipment can be prevented by not cutting the infested areas. You can dike infested areas to limit water movement out of these areas. If you have only one infested field, cut the healthy fields before taking your equipment into the infested field. After cutting the infected hay, thoroughly clean your equipment with high-pressure water or steam to remove all soil and debris. Steam cleaning is best because high temperatures will inactivate some of the fungal resting structures. If you can prevent movement of soil from the infested area, you should be able to contain movement of the disease.

Crop rotation as a means of control

Crop rotation should be effective in reducing the Verticillium inoculum for this disease. Three or four years of rotation out of alfalfa should be sufficient to sharply reduce the disease in the field, but longer rotations are desirable.

When using crop rotation to control alfalfa wilt, avoid susceptible weeds and crop plants to prevent the fungus from surviving in the absence of alfalfa. Some weeds that propagate the Verticillium attacking alfalfa are various species of plantain, klamath weed, groundsel, poppy, and dock. Recent experiments at Oregon State University suggest that potatoes, although not severely damaged by the fungus, can serve as a host for the fungus between alfalfa crops. Crop rotation to eliminate the alfalfa pathogen should avoid susceptible weeds and potatoes in the rotation sequence.

Resistant varieties

At the present time, there are no locally adapted resistant varieties, but work at Washington State University to breed resistant varieties is encouraging. Europeans have produced several good resistant varieties, and this resistance should be incorporated into new Northwest varieties shortly. Check with your Extension agent or seed supplier before planting to determine if more resistant varieties are available. Currently, three alfalfa varieties show some tolerance in limited field testing, but they are not totally resistant. They are Agate, Pacer, and Valor.

Seed treatments

Work in Europe has demonstrated that several chemicals will control Verticillium in plant debris mixed with the seed. Both fumigation and direct application of chemicals to the seed have been successful.

Several compounds for fumigation have killed the Verticillium associated with alfalfa seed. Allyl alcohol formalin, and chloropicrin were found effective, but none of these materials are registered for this use in the United States.

Two chemicals, Captan and Thiram, are registered for damping-off control in the United States. These were successful in the elimination of Verticillium from infested seed lots in Europe. If you have no Verticillium wilt, or disease occurs in only a few fields, consider using chemicals to prevent introduction of the pathogen into your fields.

One major drawback of these chemicals is their potential effect on the *Rhizobium* bacteria necessary for nitrogen fixation by alfalfa. Treat seed with the fungicide several days before the *Rhizobium* inoculation; never inoculate and treat with fungicide at the same time. Apply the *Rhizobium* inoculum immediately before seeding. Do not expose the *Rhizobium* inoculum to the fungicide for more than 3 or 4 hours before planting. If good fresh inoculum is applied in large quantity just prior to seeding, the inoculum will work in spite of the fungicide. Inoculum left in the proximity of the fungicide for more than 24 hours may be ineffective, so re-inoculate the seed.

The rate of Captan registered for use depends on the formulation and the method of application. Use 2.22 to 4.13 ounces of active ingredient per 100 pounds seed for slurry treated in a seed machine; 6.0 ounces of active ingredient per 100 pounds seed when applied dry in the machine; and 0.4 ounces of active ingredient per 100 pounds of seed when applied directly to seed on the farm in the planter box.

Thiram is registered at the rate of 6.0 ounces of active ingredient per 100 pounds of seed, regardless of the method of application.

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May 1981

Weed Control in Alfalfa

As with any crop, weeds compete with alfalfa for light, nutrients, and moisture. As a result, alfalfa growth is reduced by weed competition. Noxious or toxic weeds (tansy ragwort, black nightshade, poison hemlock, or thistle) can make a hay totally unacceptable as feed. Even non-noxious weeds will reduce the quality of alfalfa hay, as they are lower in palatability, crude protein, and digestibility. This reduced quality is often reflected in lower prices for the hay.

Cultural Control

Vigorous, dense stands of alfalfa seldom have serious weed problems. Vigorous stands are obtained and maintained by: (1) liming and fertilizing as recommended by soil analysis; (2) seeding properly inoculated, well-adapted, vigorous, long-lived varieties; (3) buying weed-free seed; (4) seeding on well-drained fields; (5) cutting the forage at first flower; (6) allowing sufficient regrowth in the fall to replenish root reserves; and (7) rotating crops to interrupt the buildup of certain weeds.

These practices will help keep alfalfa competitive with most weeds. However, some weed species may become established in spite of preventative efforts, and treating with a herbicide or returning to a cultivated row crop for several years may be necessary at times. Herbicide treatment in the absence of good cultural practices will seldom give desired results. Maximum benefits are obtained when herbicides are used in conjunction with recommended establishment and management practices.

New Seedings

Preplant herbicides

Many weed problems in alfalfa can be avoided by the use of preplant herbicides. EPTC (Eptam), benefin (Balan), and profluralin (Tolban) are preplant herbicides that require incorporation; that is, they are applied before planting and incorporated within the soil to a depth of 1 to 2 inches. These herbicides control many annual grasses (annual ryegrass, annual bluegrass, barnyardgrass, foxtails, wild oats, volunteer grains) and some annual broadleaf weeds (common chickweed, purslane, lambsquarters, knotweed, pigweed, shepherdspurse). EPTC also helps to control black nightshade, a weed that can be toxic to livestock.

Glyphosate, another herbicide that may be applied before planting to control existing vegetation, does not need to be incorporated and will not control weeds that germinate after application. It is a nonselective herbicide and controls almost all annual and many perennial grasses and broadleaf weeds if sufficient top growth is present when application is made.

Post-emergence herbicides

Broadleaf weeds (lambsquarters, pigweed, shepherdspurse, mustards) that escape preplant herbicides can be controlled with a post-emergence application of 2,4-DB or dinoseb when the weeds are small and the alfalfa has two or three true leaves. Application of propham (IPC) or chlorpropham (CIPC) when alfalfa has at least three true leaves will control many annual grasses (annual ryegrass, annual bluegrass, cheatgrass, volunteer grain, wild oats) and common chickweed. Chlorpropham will also control a number of broadleaf weeds, including carpetweed and dodder, and small plants of mustards and black nightshade.

Pronamide (Kerb) can be applied to seedling alfalfa that has at least one true leaf and will effectively control annual and perennial grasses (annual bluegrass, cereals, downy brome or cheatgrass, annual ryegrass, quackgrass, barnyardgrass, foxtails, crabgrass) and some broadleaf weeds (chickweed, sheep and red sorrel, and mustards). Chlorpropham, propham, and pronamide are most effective when applied in November or December.

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Established Stands

In established stands, alfalfa competes effectively with most annual weeds. If annual weeds are a problem in established stands, poor growing conditions or thin stands are usually the cause. Harvesting alfalfa before weeds mature their seed will keep the weeds from spreading. However, if weeds are the result of inadequate soil fertility, low soil pH, or poor drainage, these situations should be corrected or an alternative crop should be selected. Birdsfoot trefoil is a legume that is well adapted to poor drainage, low soil pH, and lower fertility levels.

Many herbicides are available for use on established alfalfa stands. Some of the compounds most commonly used in Oregon are diuron (Karmex), simazine (Princep), terbacil (Sinbar), and metribuzin (Sencor, Lexone). These materials are applied to the soil during the dormant season and will control annual weeds for a few months. Some of the weeds controlled are annual bluegrass, annual ryegrass, prickly lettuce, downy brome (cheatgrass), shepherdspurse, mustards, chickweed, lambsquarters, and dog fennel. Pronamide (Kerb) also can be used in established alfalfa stands to control many annual and perennial grasses.

In dormant alfalfa, paraquat alone or in combination with one of the soil-applied herbicides will provide effective control of annual grass and broadleaf weeds. However, extra caution is necessary when using paraquat as it is a highly toxic, restricted-use herbicide.

A complete list of herbicides registered for use in established alfalfa is provided in the *Oregon Weed Control Handbook*. Most herbicides should be applied to established alfalfa during a period of dormancy. In areas with mild winters, it is difficult to determine when plants are dormant, but a late December or January application usually results in no injury to the alfalfa.

Follow Label Directions

Good control of selected weeds can be obtained in new or established alfalfa fields by using an effective herbicide in combination with good cultural and management practices. By so doing the potential for raising high-quality, weed-free alfalfa will be increased.

By David B. Hannaway and Ralph E. Whitesides. Extension agronomists, Oregon State University.

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Oregon State University Fertilizer Guide for

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FG 18
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ALFALFA

(Willamette Valley and Northwest Oregon)

Alfalfa will produce high yields of forage when grown on deep, well drained soils.

Alfalfa removes substantial amounts of mineral nutrients. Field experiments have shown that under different conditions in western Oregon, alfalfa has profitably responded to phosphorus, potassium, sulfur, boron, and lime. The need for nutrients other than sulfur can be determined with a soil test. *With borderline test values, retest every year or every other year.*

INOCULATION

All alfalfa seed should be inoculated immediately before seeding to insure an adequate supply of nitrogen-fixing bacteria. A fresh, effective, live culture of the correct strain of Rhizobia should be used.

Additional details on legume seed inoculation are described in OSU Fact Sheet 184 "Inoculating Alfalfa and Clover Seed."

NITROGEN (N)

A response of alfalfa to applied N indicates that the alfalfa has not been effectively nodulated.

PHOSPHORUS (P)

The need for P fertilization can be determined by a soil test.

P can be applied to alfalfa fields most effectively by *banding* 1/2" to 1" to the side or below the seed when seeding. Some soil should separate seed from fertilizer.

Do not include boron in band applications.

Working P into the surface 2" of soil during seedbed preparation is more effective than broadcasting following seeding.

On new seedings:

If OSU soil test for P reads (ppm):	Apply this amount of Phosphate (P_2O_5)-(lbs/A):
0 to 10	100-150
10 to 20	70-100
20 to 40	40- 70
over 40	none

The P content of fertilizer is expressed as the oxide (P_2O_5) on fertilizer labels. Multiply P_2O_5 by 0.44 to convert to P.

On established stands:

If OSU soil test for P reads (ppm):	Apply this amount of Phosphate (P_2O_5)-lbs/A):
0 to 10	80-100
10 to 20	50- 80
20 to 40	30- 50
over 40	none

On established stands the P application should be made in the fall.

POTASSIUM (K)

Alfalfa requires large amounts of K. Available soil K may decline rapidly under established alfalfa stands. *Check soil tests every year on soils with borderlines values.* Retesting is especially important on "Red Hill" soils.

If OSU soil test for K reads (ppm):		Apply this amount of Potash (K_2O)-(lbs/A):
0- 75		150
75-150		90-150
150-200	Hill soils:	90
	Valley floor soils:	none
over 200		none

The K content of fertilizer is expressed as the oxide (K_2O) on fertilizer labels. Multiply K_2O by 0.83 to convert to K.

On new seedings:

K should be broadcast and worked into the seedbed prior to seeding.

On established stands:

On non-irrigated alfalfa broadcast K in fall or early spring.

On irrigated alfalfa apply one-half of K in fall or early spring and apply other one-half after the first cutting.

Whenever K deficiency symptoms become apparent on the alfalfa leaves, at least 90 lbs K_2O/A should be applied to provide the needs of the following crop.

A K deficiency is indicated by light colored spots around the margins of the leaves. Responses to K fertilizer are often obtained before leaf deficiency symptoms are apparent.

SULFUR (S)

Include 20 to 40 lbs S/A in fertilizer programs each year. Apply in fall or early spring. An early spring application is suggested for valley floor soils.

One ton of alfalfa hay removes about 5 lbs of S.

S is contained in several fertilizer materials used to supply other nutrients.

MAGNESIUM (Mg)

Responses to Mg applications have not been measured in alfalfa fertility experiments to date. Trial applications are suggested when soil test values are below 0.8 meq Mg/100g or when the amount of calcium is more than ten times the amount of Mg.

Mg can be applied in the form of dolomite lime which is equal to ground limestone in reducing soil acidity.

BORON (B)

The following suggestions are for established alfalfa stands. The application of B to new alfalfa seedings is not recommended.

If OSU soil test for B reads (ppm):	Apply this amount of B (lb/A):
0 to 0.7	4 (initial application) then 2-3 annually
0.7 to 2.0	2-3
over 2.0	none

B should not be banded.

B and other materials should be thoroughly mixed when B application is combined with other fertilizers.

B can be toxic if applied at rates higher than recommended.

B should be applied in fall or early spring.

Response to B is most apparent on second or third cutting.

LIME

Alfalfa is sensitive to soil acidity and is responsive to liming of acid soils. Lime should be applied when the pH of the soil is below 6.4 or the OSU soil test for calcium, is below 5 meq Ca/100g of soil.

If the OSU SMP Buffer test for lime reads:	Apply this amount of lime (T/A):
below 5.2	5-7
5.2-5.5	4-5
5.5-6.0	3-4
6.0-6.4	2-3
6.4-6.6	1-2
over 6.6	0

The suggested liming rate is based on dry 100 score lime. Liming materials should be checked for moisture content and score.

Apply lime several weeks before seeding and thoroughly mix with the surface 5 to 6 inches of soil.

A lime application is effective over several years.

Broadcasting lime on established alfalfa fields is not an effective practice.

Dolomite lime, which can be used as a source of Mg, is equal to ground limestone in reducing soil acidity.

P, K, Mg, B, and lime applications are based on soil test values from the Soil Testing Laboratory OSU, Corvallis, Oregon.

Suggested fertilizer applications based on experiments conducted by T. L. Jackson, E. Hugh Gardner, Hugh Hickerson, and Fremont Sprowls, OSU Agricultural Experiment Station and Extension Service.

Prepared by E. Hugh Gardner, Soil Science, and Lester Vough, Agronomic Crop Science, Extension Service; and T. L. Jackson and W. S. McGuire, Agricultural Experiment Station, Oregon State University. Reviewed by a committee of northwest Oregon County Extension Agents.

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FG 60
October 1976

Oregon State University Fertilizer Guide for

ALFALFA

(Southwest Oregon)

Alfalfa will produce high yields of forage when grown on deep, well drained soils.

Alfalfa removes substantial amounts of mineral nutrients. Field experiments have shown that under different conditions in western Oregon, alfalfa has profitably responded to phosphorus, potassium, sulfur, boron, and lime. The need for nutrients other than sulfur can be determined with a soil test. *With borderline test values, retest every year or every other year.*

INOCULATION

All alfalfa seed should be inoculated immediately before seeding to insure an adequate supply of nitrogen-fixing bacteria. A fresh, effective, live culture of the correct strain of Rhizobia should be used.

Additional details on legume seed inoculation are described in OSU Fact Sheet 184 "Inoculating Alfalfa and Clover Seed."

NITROGEN (N)

A response of alfalfa to applied N indicates that the alfalfa has not been effectively nodulated.

PHOSPHORUS (P)

The need for P fertilization can be determined by a soil test.

P can be applied to new alfalfa seedings most effectively by *banding* 1/2" to 1" to the side or below the seed when seeding. Some soil should separate seed from fertilizer.

Do not include boron in band applications.

Working P into the surface 2" of soil during seedbed preparation is more effective than broadcasting following seeding.

On established stands the P application should be made in the fall.

If OSU soil test for P reads (ppm):	Apply this amount of Phosphate (P_2O_5)-(lbs/A):
0 to 5	80-100
5 to 10	60-80
10 to 20	40-60
over 20	none

The P content of fertilizer is expressed as the oxide (P_2O_5) on fertilizer labels. Multiply P_2O_5 by 0.44 to convert to P.

POTASSIUM (K)

Alfalfa requires large amounts of K. Available soil K may decline rapidly under established alfalfa stands. *Check soil tests every year on soils with borderline values.*

If OSU soil test for K reads (ppm):	Apply this amount of Potash (K_2O)-(lbs/A):
0- 75	80-100
75-100	60- 80
Over 100	0

The K content of fertilizer is expressed as the oxide (K_2O) on fertilizer lables. Multiphy K_2O by 0.83 to convert to K.

On new seedings:

K should be broadcast and worked into the seedbed prior to seeding.

On established stands:

On non-irrigated alfalfa broadcast K in fall or early spring.

On irrigated alfalfa apply one-half of K in fall or early spring and apply other one-half after the first cutting.

Whenever K deficiency symptoms become apparent on the alfalfa leaves, at least 80 lbs K_2O/A should be applied to provide the needs of the following crop.

A K deficiency is indicated by light colored spots around the margins of the leaves. Responses to K fertilizer are often obtained before leaf deficiency symptoms are apparent.

SULFUR (S)

Include 20 to 40 lbs S/A in fertilizer programs each year. Fall or early spring application is satisfactory.

One ton of alfalfa hay removes about 5 lbs of S.

S is contained in several fertilizer materials used to supply other nutrients.

MAGNESIUM (MG)

Responses to Mg applications have not been measured in alfalfa fertility experiments to date. Trial applications are suggested when soil test values are below 0.8 meq Mg/100g or when the amount of calcium is more than ten times the amount of Mg.

Mg can be applied in the form of dolomite lime which is equal to ground limestone in reducing soil acidity.

BORON (B)

The following suggestions are for established alfalfa stands. The application of B to new alfalfa seedings is not recommended.

If OSU soil test for B reads (ppm):	Apply this amount of B (lb/A):
0 to 1.0	2
Over 1.0	0

B should not be banded.

B and other materials should be thoroughly mixed when B application is combined with other ferilizers.

B can be toxic if applied at rates higher than recommended.

B should be applied in fall or early spring.

Response to B is most apparent on second or third cutting.

LIME

Alfalfa is sensitive to soil acidity and is responsive to liming of acid soils. Lime should be applied when the pH of the soil is below 6.4 or the OSU soil test for calcium is below 5 meq Ca/100g of soil.

If the OSU SMP Buffer test for lime reads:	Apply this amount of lime (T/A):
below 5.2	5-7
5.2-5.5	4-5
5.5-6.0	3-4
6.0-6.4	2-3
6.4-6.6	1-2
Over 6.6	0

The suggested liming rate is based on dry 100 score lime. Liming materials should be checked for moisture content and score.

Apply lime several weeks before seeding and thoroughly mix with the surface 5 to 6 inches of soil.

A lime application is effective over several years.

Broadcasting lime on established alfalfa fields is not an effective practice.

Dolomite lime, which can be used as a source of Mg, is equal to ground limestone in reducing soil acidity.

P, K, Mg, B, and lime applications are based on soil test values from the Soil Testing Laboratory, OSU, Corvallis, Oregon.

Suggested fertilizer applications based on experiments conducted by John Yungen, Oregon Agricultural Experiment Station.

Prepared by E. Hugh Gardner and Gary Schneider, Extension Service; and W. L. Jackson, W. S. McGuire, and John Yungen, Agricultural Experiment Station, Oregon State University.
Reviewed by a committee of southwest Oregon County Extension Agents.

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FG 20
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ALFALFA

(Eastern Oregon - East of Cascades)

Good management practices are essential if optimum fertilizer responses are to be realized. These practices include use of recommended varieties, selection of adapted soils, weed control, disease and insect control, good seed bed preparation, proper seeding methods, and timely harvest.

Because of the influence of soil type, climatic conditions, and cultural practices, crop response from fertilizer may not always be accurately predicted. Soil test results, field experience, and knowledge of specific crop requirements help determine the nutrients needed and the rate of application.

Recommended soil sampling procedures should be followed in order to estimate fertilizer needs. Your county agent can provide you with soil sampling instructions, soil sample bags and information sheets.

Alfalfa is the principal legume grown for hay in eastern Oregon and will produce high yields of good quality forage, particularly when grown on deep, well-drained soils. In low rainfall areas adequate and timely irrigation is essential to good alfalfa yields.

In field experiments some responses of alfalfa to applications of phosphorus, sulfur, potassium, boron and lime have been obtained. Soil testing should be used as a basis for fertilizer applications.

INOCULATION

All alfalfa seed should be inoculated immediately before seeding to insure an adequate supply of nitrogen-fixing bacteria. A fresh, effective, live culture of the correct strain of Rhizobia should be used. Effective inoculation can be reduced when alfalfa is seeded into soil containing a high level of available N such as might occur following peppermint, potatoes or some other heavily N fertilized crop. Additional details on legume seed inoculation are described in OSU Fact Sheet 184 "Inoculating Alfalfa and Clover Seed."

NITROGEN (N)

A response of alfalfa to applied N usually indicates that the alfalfa has not been effectively nodulated. N fertilizer can reduce effective nodulation. N is sometimes applied when mono-ammonium phosphate (11-48-0) is used as the P source. The small amount of N (usually less than 15 lb N/A) applied in this way should not interfere with nodulation. Grass grown in combination with alfalfa can respond to N fertilizer, but this may reduce the growth of alfalfa.

PHOSPHORUS (P)

The need for P fertilization can be determined by a soil test.

If OSU soil test for[1] P reads (ppm)	Apply this amount of phosphate (P_2O_5)-(lbs/A)
0 to 5	80-120
5 to 15	40- 80
over 15	none

[1]This soil test is based on a 0-12" soil sample and the Olsen sodium bicarbonate procedure as outlined in the OSU Soil Analysis Methods Report.

P can be applied to alfalfa fields most effectively by banding 1/2 to 1" to the side or beneath the seed. Some soil should separate fertilizer from the seed. *Do not include boron in band applications.* Working P into the seedbed prior to planting is more effective than broadcasting following seeding.

Where soil tests on an established stand indicate a P deficiency, P should be broadcast during the fall to early spring period.

POTASSIUM (K)

Most of the soils in eastern Oregon contain adequate amounts of K for alfalfa production. *The need for K fertilization can be determined by a soil test.*

If OSU soil test for[1] K reads (ppm):	Apply this amount of potash (K_2O)-(lbs/A)
0 to 75	100-200
75 to 150	50-100
over 150	none

[1]This soil test is based on a 0-12" soil sample and the ammonium acetate procedure as outlined in the OSU Soil Analysis Methods Report.

K can be supplied most effectively by working into the seedbed prior to planting. On established stands, K should be applied in the fall to early spring period.

Alfalfa requires large amounts of K. Available soil K may decline rapidly under established alfalfa stands. Check soil tests every year on soils with borderline values.

Whenever K deficiency symptoms become apparent on the alfalfa leaves, at least 90 lbs K_2O/A should be applied to provide the needs of the following crop.

A K deficiency is indicated by light colored spots around the margins of the leaves. Responses to K fertilizer are often obtained before leaf deficiency symptoms are apparent.

SULFUR (S)

S fertilizer requirements will vary with soil texture, leaching losses, S content of irrigation water, and the soil parent material. Soils developed on pumice in central Oregon have a particularly high S requirement.

1. In central Oregon, 80 to 100 lbs S should be applied annually on sandy loam and loamy sand soils; 40 to 60 lbs S should be applied annually on silt loam and finer-textured soils.

2. In north central, south central, and northeast Oregon, 15-40 lbs S/A should be applied on an annual basis. Each ton of alfalfa hay will remove 5 to 8 lbs S. Two years' needs for S can be provided by applying double the recommended annual rate.

3. S response has not been measured on some soils, such as the river bottom soils in Crook County and Malheur or Harney counties.

4. S fertilizers should be applied in the fall or early spring.

5. When elemental S is used as the S fertilizer, application every second year is sufficient. Elemental S used as S fertilizer should be finely ground so that all will pass through a 32 mesh sieve and most will pass a 60 mesh sieve.

6. The use of elemental S tends to make soil become acid. Gypsum can be used as a source of S without affecting soil acidity.

7. As elemental S gives a slow response, it is not recommended for application to alfalfa fields where S deficiency symptoms are apparent. In this case a more rapidly available form of S such as gypsum should be applied.

8. S is frequently applied as a component of fertilizer materials such as single superphosphate.

9. Much of the irrigation water contains appreciable amounts of S which can be utilized by plants. Water containing 1 ppm S would supply 2.72 lbs S/A for each foot of water applied. Growers should have their irrigation water analyzed to determine its S content.

A soil test will provide information about the need for S fertilizer. It is recommended that soil samples for sulfate (SO_4-S) analysis be taken to a depth of 24 inches. Based on a 0-24" soil sample, the soil test value (ppm) is multiplied by a factor of 8 to convert to lbs of SO_4-S/A. Thus a soil test value of 6 ppm SO_4-S for a 0-24" soil sample would equal 48 lbs of SO_4-S/A.

BORON (B)

Responses of alfalfa to B fertilizer vary in the different areas of eastern Oregon.

In central Oregon experiments, responses to B have not been observed. In this region, B applications are suggested on a trial basis where the soil test value is below 0.3 ppm.

In other areas of eastern Oregon, if the OSU soil test for B is less than 0.50 ppm, 2 to 4 lbs B/A should be applied.

B should not be banded close to the seed.

MAGNESIUM AND MICRONUTRIENT ELEMENTS

An economic response of alfalfa from the application of magnesium and micronutrients, except B, has not been obtained in field experiments.

LIME

Soil tests show that a number of surface soils in eastern Oregon have a pH value low enough to cause some concern about the need for lime. Before recommending lime, soil samples, including sub-soil samples, should be submitted for analysis. In cases where the sub-soil contains calcareous material, an acid surface soil condition can be corrected by deep plowing.

Where the pH of the surface soil is less than 6.5 and deep plowing does not correct the acidity liming of alfalfa fields is suggested.

If the pH of the surface 12" of soil reads	Apply this amount of lime (T/A): Sandy Soil	Silt & Clay Loam Soils
Below 5.5	1.5-2	2-3
5.5 - 5.9	1 -1.5	1-2
6.0 - 6.5	1	1
Over 6.5	0	0

The suggested liming rate is based on 100 score lime.

Apply lime several weeks before seeding and thoroughly mix with the surface 5 to 6 inches of soil.

A lime application is effective over several years.

Broadcasting lime on established alfalfa fields is not an effective practice.

P, K, B, and lime recommendations are based on soil test values from the Soil Testing Laboratory, OSU, Corvallis, Oregon.

Recommendations based on experiments conducted by Vance Pumphrey and Malcolm Johnson, OSU Agricultural Experiment Station, and Harold Kerr, Thomas Thompson, Martin Zimmerman, Bert Wilcox, and E. Hugh Gardner, OSU Extension Service.

Prepared by E. Hugh Gardner, Vance Pumphrey, Malcolm Johnson, T. L. Jackson, David Hannaway, Bert Wilcox, and Lynn F. Hall, Extension Service and Agricultural Experiment Station, Oregon State University, Corvallis, Oregon. Reviewed by a committee of Eastern Oregon County Extension Agents.

OREGON STATE UNIVERSITY EXTENSION SERVICE

ALFALFA HAY (Dryland)
Mid-Willamette Valley

Based on:

1. 60 Ac. alfalfa on 300 Ac. farm
2. 5 Ton per Acre yield
3. 4 Producing years
4. Prevailing custom rates 1/
5. Hired labor @ 4.50/hr. 1/
6. Skilled labor @ 8.00/hr.

PRODUCING YEAR	INPUTS PER ACRE		
		Total Cost	Your Cost
Cultural Operations 2/		($)	($)
Fertilize (2x)	Custom	48.00	
Rodent Control	Time & Material	10.00	
Mow & Condition (3x)	Custom	30.00	
Rake (7x)	Custom	28.00	
Baling	Custom	80.00	
Loading & Stacking	Custom	25.00	
Weed Control	Custom	20.15	
Other Charges			
Land Charge 3/		90.00	
Operating Cap. Int. (14.5%)		11.65	
General Overhead 4/		25.30	
Management		6.00	
Amortized Establishment Cost		113.80	
Cash Cost		278.10	
Non-Cash Cost		209.80	
Total Cost		487.90	
Cost per ton 5 ton yield		97.60	
Cost per ton 6 ton yield		84.70	
Cost per ton 4 ton yield		116.75	

1/ Includes SAIF and other payroll expenses.

2/ See your County Extension Agent for specific recommendations.

3/ Based on rental value.

4/ 10% of cash costs.

These data were obtained and developed by Gale Gingrich and Hugh Hickerson, Extension Agents in cooperation with Mid-Willamette Valley alfalfa growers.

Department of Agricultural and Resource Economics

June 1980

ESTABLISHMENT YEAR

	Labor			Other		Total
	Hrs.	Value	Machinery	Item	Value	Cost
Cultural Practices [1]		($)	($)		($)	($)
Plow	.33	2.65	6.40			9.05
Wheel Harrow (2x)	.33	2.65	3.70			6.35
Lime (3 Ton) [2]				Custom	57.20	57.20
Field Cultivate & Harrow (3x)	.50	4.00	9.70			13.70
Preplant Herbicide				Custom	18.50	18.50
Incorporate Herbicide	.33	2.65	6.35			9.00
Cultimulch (4x)	.60	4.80	13.45			18.25
Drill	.20	1.60	3.60	Seed	42.00	
				Fert	35.00	82.20
Clip	.20	1.60	3.15			4.75
Other Charges						
Land charge					90.00	90.00
Operating Cap. Int. (14.5%)					20.75	20.75
General Overhead					17.35	17.35
Management					6.00	6.00
Cash Cost		-0-	20.85		190.80	211.65
Non-Cash Cost		19.95	25.50		96.00	141.45
Total Cost		19.95	46.35		286.80	353.10
Amortized Establishment Cost (4 years @ 11%)						113.80

1/ See your County Extension Agent for specific recommendations.
2/ Lime charged for 5 out of 8 years to alfalfa.

OREGON STATE UNIVERSITY EXTENSION SERVICE

ALFALFA HAY
Klamath Basin

Based on:

1. 300 acres alfalfa with 5-ton ave. yield
2. 6 producing years after establishment
3. 2.5 cuttings per year (third cutting three out of six years)
4. Operational costs based on local custom rates
5. Side-roll wheel line irrigation.
6. Machinery operator labor $5.50 per hr.

PRODUCING YEARS — INPUTS PER ACRE

Item	Labor Hrs.	Labor Value ($)	Machinery ($)	Other Item	Other Value ($)	Total cost ($)	Your cost ($)
Cultural Operations[1]							
Fertilize				Custom[2]	8.00	8.00	
Pest control				Custom[3]	24.00	24.00	
Irrigate (5x)	2.25	12.40	30.00	Water	8.00		
				Elec.	3.00	53.40	
Harvest Costs (5 ton yield)							
Swath (2.5X @ $8.00/ac.)				Custom	20.00	20.00	
Rake (2.5X @ $2.00/ac.)				Custom	5.00	5.00	
Bale @ $13.00/ton				Custom[4]	65.00	65.00	
Haul @ $5.00/ton				Custom	25.00	25.00	
Other Charges							
Interest on land ($1200 @ 12%)					144.00	144.00	
Taxes on land					10.00	10.00	
Operating capital interest (14%)					9.60	9.60	
General overhead					15.00	15.00	
Total Cash Costs		12.40	10.00		192.60	215.00	
Total Non-Cash Costs		0	20.00		144.00	164.00	
TOTAL COSTS (Producing Year)		12.40	30.00		336.60	379.00	
Amortized establishment costs						106.35	
Total Cost (including establishment)						485.35	
Cost Per Ton[5]							
4 ton yield						116.84	
5 ton yield						97.07	
6 ton yield						83.89	

(Footnotes on other side)

These data were obtained and computed by county agent Rodney Todd in cooperation with Klamath Basin hay producers.

Department of Agricultural and Resource Economics, March 1980.

ESTABLISHMENT YEAR[6/] INPUTS PER ACRE

Item	Hrs.	Value ($)	Machinery ($)	Other Item	Other Value ($)	Total cost ($)	Your cost ($)
Cultural Operation[1/]							
Primary tillage[7/]	1.0	5.50	19.50			25.00	
Disc (2X)	.5	2.75	6.00			8.75	
Preplant weed control				Mtls.	10.00		
				Custom app.	2.75		
				Incorporate	15.00	27.75	
Land plane (2X)[8/]	.5	2.75	8.00			10.75	
Seed and roll (2-way)	.5	2.75	16.00	Seed	45.00	63.75	
Irrigate (8X)	3.5	19.25	30.00	Water	8.00		
				Elec.	3.00	60.25	
Fertilize				Mtls.[9/]	57.25		
				Custom app.	2.75	60.00	
Other Charges							
Interest on land ($1200 @ 12%)					144.00	144.00	
Taxes on land					10.00	10.00	
Operating capital interest (14%)					12.10	12.10	
General overhead					15.00	15.00	
Total Cash Costs		2.75	35.75		180.85	219.35	
Total Non-Cash Costs		30.25	43.75		144.00	218.00	
TOTAL COST (for establishment)		33.00	79.50		324.85	437.35	
Annual amortized establishment cost, (6 years @ 12%, 0.2432)						106.35	

[1/] Consult your county agent for recommendations on specific practices.

[2/] Fertilize every other year.

[3/] Weed, apnid, and weevil control every other year. Squirrel and gopher control as required.

[4/] Wire cost included.

[5/] Including storage, insurance and shrinkage charges.

[6/] Establishment year costs assume land was used for grain production the previous year.

[7/] Deep ripping, plowing or similar operation.

[8/] Smoothing, not heavy planing.

[9/] Fertilizer is 1,000 lbs. single super P_2O_5.

OREGON STATE UNIVERSITY EXTENSION SERVICE

ALFALFA
Hermiston Area

Based on:

1. 390 acres of alfalfa.
2. Five year stand life.
3. Normal yield of 6 tons per acre.
4. Machinery labor @ $6.25/hr.
5. Other labor @ $5.00/hr.
6. Side-roll irrigation system.

INPUTS PER ACRE

Producing Years	Labor Hrs.	Labor Value ($)	Machinery & Equipment Operating[1] ($)	Machinery & Equipment Ownership[2] ($)	Other Item	Other Value ($)	Total cost ($)
Cultural Operations[3]							
Spray					Mtls.	9.00	
					Custom	3.25	12.25
Fertilizer					Mtls.	12.00	
					Custom	3.50	15.50
Gopher Control[4]	.13	.80	.30	.50	Mtls.	.60	2.20
Irrigate	6.08	30.40	6.45	34.00	Water Dist.	5.00	
					Power	20.20	96.05
Harvesting Costs							
Swath (3x) 5/	1.00	6.25	7.60	23.95			37.80
Bale (3x) 6/	1.20	7.50	7.85	35.35	Wire	16.00	66.70
Stacking ($7.00/ton)					Custom	42.00	42.00
Other Charges							
Loading ($2.00/ton)					Custom	12.00	12.00
Operating capital int. 7/						13.05	13.05
Land Taxes 8/						10.00	10.00
Interest on land ($1500 @ 11%)						165.00	165.00
Management 9/						19.30	19.30
Overhead 10/						14.50	14.50
Total Cash Costs		30.40	22.20	1.80		165.90	220.30
Total Non-Cash Costs		14.55	-	92.00		179.50	286.05
TOTAL COSTS PER ACRE (Prod.yr.)		44.95	22.20	93.80		345.40	506.35
AMORTIZED ESTABLISHMENT COSTS (5 yrs. @ 11%)							54.00
TOTAL COSTS FOR PRODUCING YEAR PLUS AMORTIZED ESTABLISHMENT							560.35
Cost per ton @ 4 tons per acre							131.02
Cost per ton @ 6 tons per acre							93.39
Cost per ton @ 8 tons per acre							74.56

(Footnotes on back)

These data were obtained and computed by Lynn Hall, Extension Agent, Umatilla County, in cooperation with Hermiston area alfalfa producers.

Department of Agricultural and Resource Economics, March 1980.

Establishment Year[11]	Labor Hrs.	Labor Value ($)	Machinery & Equipment Operating[1/] ($)	Machinery & Equipment Ownership[2/] ($)	Other Item	Other Value ($)	Total cost ($)
Cultural Operations[3/]							
Plow	.21	1.30	2.00	5.40			8.70
Disc and pack	.20	1.25	2.30	3.45			7.00
Land plane (2x)	1.00	6.25	6.95	10.10	Rental	5.60	28.90
Drill	.30	1.90	2.90	5.40	Seed	62.00	72.20
Fertilize					Mtls.	48.40	
					Custom	3.50	51.90
Irrigate	.84	4.20	.90		Power	2.80	7.90
Other Charges							
Operating capital interest[7/]						9.90	9.90
Management 9/						7.45	7.45
Overhead 10/						5.60	5.60
TOTAL ESTABLISHMENT COSTS		14.90	15.05	24.35		145.25	199.55
AMORTIZED ESTABLISHMENT COSTS (5 yrs. @ 11%)							54.00

1/ Includes fuel, lubrication, and repairs.

2/ Includes depreciation, interest on average investment, and insurance.

3/ Assumes: (1) 130 hp. four wheel drive tractor @ $17.00 per hour and (2) 100 hp. tractor @ $13.40 per hour.

4/ Gopher control is based on treating half the acreage each year.

5/ Assumes a self-propelled swather @ $31.50 per hour.

6/ Assumes a PTO baler @ $22.60 per hour.

7/ Assumes that the cash expenses are outstanding for half a year with a 13% annual interest charge.

8/ Based on farm use value.

9/ Approximately 4% of all costs except overhead.

10/ Approximately 3% of all costs except management.

11/ Alfalfa is assumed to be established in the fall. In this context irrigation ownership costs, water district charges, land taxes, and interest on land investment have been assigned to the prior crop.

Pasture Management and Production

Instructional Materials

Pasture Management in Western Oregon

Grazed forage from pastures is the basis of most livestock operations and results in efficient use of land resources. Forage is the basic product available for market, and the best way to do that is with livestock. Even so, pasture management often is relegated to low priority.

Western Oregon weather imposes variations and limitations in pasture management. On the average, fall rains break the summer dry period by early October. Forage growth is relatively slow and is limited by cool temperatures from that time through the winter. Sometime from mid-March to mid-April, depending on the location and the year, temperatures warm enough for plant growth to improve. In the 6-week period from late April to early June, more than half of the year's total production takes place on nonirrigated pastures. Then a dry period of about 3 months challenges the operator to find enough high quality feed.

This kind of weather pattern, with certain geographical exceptions, provides an exceptionally good environment for forage plant growth when compared to many other parts of the United States. What does one need to know in order to establish and maintain a productive pasture in this kind of environment? What are the requirements for productive plant growth? How can grazing animals best be managed so that both high plant and animal productivity occur? These and other management questions are answered here.

Basic Principles

Grazing animals should be provided with forage plants they prefer to eat. Improved pastures will help make this possible. This is *fitting the resources to the animal.* In this case, we plant the desired species, apply appropriate kinds and amounts of fertilizers, irrigate if that is possible or practicable, and perhaps even mow or spray for weed control.

Conversely, when pastures have not been or cannot be planted with improved species, the effort must be to *fit the animals to the resources.* In such situations try to match the number of animals to the most opportune grazing time for the major forage species. Pasture fertilization, irrigation, and weed control generally are not part of the management program. Proper forage utilization becomes the key to successful management.

The land resources at your disposal and the intensity of management that you wish to give have a great bearing on overall productivity. For example, if a properly seeded and fertilized pasture is not given adequate grazing management, the potential for production will not be achieved. Likewise, well managed grazing of a seeded pasture, without correct fertilization and irrigation, will not result in the highest level of animal production.

Plant growth processes

Each plant species undergoes a sequence of development from starting growth in the fall until completing it the following summer. All plants require water, nutrients, and optimum temperatures for best growth. These requirements vary somewhat from species to species. Fortunately, effective management schemes can be developed for many different pasture mixtures. Perennial species such as tall fesuce and perennial ryegrass are dormant after they mature. But annuals, such as subterranean clover, die after maturity. Annual plants survive by producing seed. Therefore, you should provide for seed p.oduction in order to perpetuate annuals. Perennials live from year to year because their roots and crowns stay alive over the summer dry period. The vigor of some perennials may be impaired, however, if the opportunity to restore root reserves is not provided.

Perennial grasses and legumes store carbohydrates in their roots and crowns and draw on that stored energy to make new growth. Each fall some of this stored energy is drawn for new leaf growth. There is a time in the growth cycle of perennial plants when the plant makes more energy than it uses. During this time the surplus energy accumulates in the roots and crowns. The process is at its peak at the time of flowering and is complete by the time seed has been formed.

Grazing at the wrong time, especially if too severe and too long, can damage the plant by not allowing it to restore energy

Prepared by Thomas E. Bedell, Extension rangeland resources specialist, Oregon State University.

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Oregon State University Extension Service

reserves. If this practice is continued, the plant declines in vigor. This permits other, less palatable plants to increase and compete with the desired species.

Annual plants such as subclover develop a completely new root system every year. After germination, allow this root system to develop. But, once the annual has developed a root system, the tops can be grazed. It then is important to tailor the amount of grazing to the amount of top growth, since if all top growth were continuously removed, the plant would be greatly weakened. Relax the grazing pressure periodically to allow pasture plants to recover.

Many plants, whether perennial or annual, have an ability to tiller or "stool out." This is the plant's productioin of additional, new basal stems. Some plants tend to grow in a more prostrate form than others, and early grazing tends to stimulate this desirable habit of growth. As long as grazing pressure is not too heavy and openings are not made in the plant cover, damage will not result.

Grazing management

Forage is often wasted through inadequate control of animals. The most common sign of wasted forage is patch grazing —a few areas overused while most of the pasture remains underused. Animals will graze regrowth repeatedly in small areas and allow other plants to reach maturity. This is because the regrowth is of younger, more succulent, and probably more nutritious plant tissue. Often more than 1 year's growth may accumulate, resulting in low quality forage. This can happen, and often does happen, even when only a single species is used in a pasture. Inefficient utilization can be avoided by matching the grazing pressure to the forage supply.

Efficient utilization can be accomplished by subdividing pastures, with fences, into several units and moving stock in accordance to a plan based on the kinds of pasture species. Close control of grazing livestock is the key to correct and proper utilization. Often, so much growth occurs during April, May, and June that it is desirable to make some of it into hay.

Pastures deteriorate for a number of reasons. Most often, part of the cause is improper grazing control. Underutilization by grazing animals can account for a decline in productivity. Do not allow the plant cover to open up, since this permits weed invasion and rodent infestation.

Sheep prefer fine, succulent forage, and generally concentrate on broadleaf plants, especially legumes. Mature cattle eat upright, coarse species better than do sheep. Young animals, whether calves or lambs, prefer young, green plants, and do not grow well when they are confined to more mature plants, even of the generally palatable species. Grazing animals will prefer regrowth of a plant to the same plant that has not been grazed previously.

Young plants contain higher levels of protein, phosphorus, and readily digestible carbohydrates than do older plants. Very immature plants during fall, winter, and early spring may contain so much moisture that high producing animals cannot obtain enough dry matter through grazing. Before the seedhead stage most grasses and legumes contain balanced amounts of protein, major mineral elements, and energy so that grazing animals seldom need a supplement other than trace mineralized salt. Immature stages of plants, however, can contain the highest levels of molybdenum, wide copper-molybdenum ratios, low selenium, and low calcium and magnesium, which could result in less than optimum animal nutrition. Consequently, you should monitor the condition of the animal regardless of stage of plant growth.

Improved Pastures

Planting improved species (fitting resources to the animal) will result in greater forage production and forage more tolerant to grazing pressure than leaving a pasture in native species. In western Oregon more than 6,000 pounds of dry forage per acre is possible on dryland by seeding and good management. More than 300 pounds of lamb gain or 600 pounds of yearling steer gain per acre have been achieved in research studies. Proper management practices will provide these levels of productivity.

When you have made the decision to invest in the development and long term maintenance of seeded pastures, intensive management will be necessary in order to realize the greatest return for the investment of money, time, and effort. Thus, you should make the commitment to a high level of management at the time the project is started. An example of this is the difference between a pasture mixture of perennial ryegrass and subterranean clover and that of tall fescue and subclover. The former needs a higher level of management—fertilization and grazing control. Tall fescue will survive and persist if improperly managed, but, the clover will go out of the stand and the forage will be much less palatable and less digestible. Perennial ryegrass needs more nitrogen than tall fescue, preferably provided from associated legumes.

Irrigated pastures will be composed of different species than dryland pastures. Levels of production in irrigated pastures can be quite high (12,000 pounds dry matter per acre), which makes attention to grazing control extremely important. Whereas production from dryland pastures can be 6 to 8 animal-unit-months per acre, that from irrigated pastures is often 12 to 14 or more.

Plant species selection

Only two considerations need be made regarding plant species selection: (1) What is the site adaptability, that is, will the plants grow and reproduce? and (2) What are the uses to be made of the forage? Answers to the first question will limit answers to the second.

The annual legume, subclover, often is planted on non-irrigated soils. With it, perennial ryegrass, tall fescue, and/or orchardgrass may be planted. All these species grow during winter, but make greatest growth in spring from March to June. More than half of the annual growth occurs from late April through May, which makes proper utilization with livestock difficult. Excess forage during this period is generally harvested for hay or silage and stored for winter feed. For irrigated pasture, white clover will replace subclover. It can be used on the more damp dryland areas. White clover is a perennial, spreading by runners and seed. Both subclover and white clover tolerate grazing well.

Establishment

Thousands of acres of trees and brush have been cleared by bulldozing and improved pastures established without preparing complete seedbeds on lands freshly cleared. The soil surface often is both firm enough and smooth enough for successful establishment. Most operators, however, will be either replanting pastures or converting land from a crop to a pasture.

A fine, firm, weed-free seedbed is necessary. A rule of thumb is that your heel should not sink in more than ½ inch when you walk across a field ready for planting. Visualize planting your pasture as you would a garden or a new lawn. Once the seed is planted, it is too late to do much else to help it along. As a general rule, cultivation more than 6 inches deep is not necessary. Except for annual clovers, perennial species with relatively deep root systems, capable of penetrating uncultivated soil, are usually planted. Control of weed competition is important. Whenever practical, summer fallowing before planting the pasture will help greatly, since the purpose

is to stimulate germination of weeds and then cultivate them out. Often, planting a highly competitive interim crop will help suppress weeds. And, the interim crop will provide some needed livestock feed, too. Herbicides may help under special weed conditions, but usually are not necessary.

Test soil from the upper 4 to 6 inches well ahead of planting time so appropriate fertilizers and/or soil amendments can be added. Lime is often needed to counteract soil acidity. Work it into the upper 2 inches during seedbed preparation. Do not plow it under, since this will remove it from the seedling rooting zone. Incorporate fertilizers such as phosphorus, sulfur, and potassium into the seedbed. If a seeding drill with a fertilizer feeding mechanism is available, fertilizers can be banded during the drilling operation. Do not band boron, however, as high concentrations are toxic to seedling development. Where irrigation water can be applied following planting, light rates of nitrogen (approximately 35 pounds per acre) will be beneficial in getting grass off to a good start. Consult your county Extension agent for specific fertilizer recommendations.

Clean seed is a must. Percent purity is noted on the seed tag. Strive to get the cleanest, highest-percent-germination seed possible. Remember that desirable plants can come only from pure, live seed of the species and variety that you want. To ensure varietal purity, purchase certified seed whenever possible. Although seed prices may appear expensive, the seed cost per acre is relatively minor compared to cultural and fertilization costs.

Seeding conditions and seeding rates are both important. A good rule of thumb is to plant just deep enough so all seeds are covered. Soil should be firm both beneath the seed and above it. Only when soil is in close contact with seed will it have the opportunity to germinate rapidly and evenly. When soil is firm around seed, capillary action will allow existing soil moisture its maximum chance to provide germination conditions. And, when moisture does come, it will be more effective when seed is in close contact with soil.

Increase the rate of seeding if seedbed conditions are less than optimum. For example, when seed cannot be drilled precisely and must be planted either with poor equipment or broadcast and then covered, increase the seeding rate by 50 percent above that recommended for optimum planting conditions. Or, when severe soil conditions exist, such as occur with heavy clays or light sands, you should increase the seeding rate. When a dense stand is desired quickly, more seed is necessary. For most pasture species, however, there will be five or more seeds per square foot planted if only 1 pound were planted per acre. Subclover is an exception; it would have only 1.7 seeds per square foot if 1 pound per acre were planted. Consult a local Extension agent for recommended seeding rates.

Time of seeding is important. Plant dryland pastures in September, before fall rains, or just as soon as possible after fall rains. The objective is to obtain early germination of grasses and legumes so they will become as large as possible before cold winter weather. Where irrigation is possible, spring planting usually is preferable, although timing is less critical with irrigation.

Inoculate legume seeds with an approved inoculant before seeding. This is cheap insurance. Be sure the inoculant you buy is not outdated and that it has been kept cool in storage. Host-specific *Rhizobia*, applied to the seed, invade the small new root and cause the plant to form nodules. These bacteria have the ability to make the nitrogen in the air available for plant use. As the roots die, the nitrogen within the soil system becomes available to all plants. If legumes do not become well nodulated, their productivity is sharply reduced; quite often they do not establish if not nodulated. Even in soils that have adequate supplies of the right bacteria, legumes should be inoculated with the proper bacteria.

Fertilization

Add fertilizers, except nitrogen, in September, before fall rains occur. Needs on dryland grass-clover pastures are primarily for phosphorus and sulfur. Oregon State University Fertilizer Guides FG 1, 4, 58, and 68 will be helpful. Obtain and pay particular attention to the phosphorus, sulfur, and molybdenum recommendations. Extra winter grass growth can be stimulated with fall applied nitrogen but this is not a general practice. Nitrogen at rates of 30 to 40 pounds per acre, applied in March, will stimulate earlier spring grass growth when a vigorous clover stand is not present. However, reliance on nitrogen can stimulate grass to the detriment of clover. This is generally considered undesirable. As stated, maintenance of a dense clover stand should contribute to good soil nitrogen status. Where pastures are irrigated, applying nitrogen fertilizer several times during the growing season before irrigations is preferable to one large application. This will result in more uniform forage production rather than one large flush of growth with a tailing-off effect.

Grazing management

Proper grazing will have more to do with maintaining high production than any other single factor. The kind of animal used will have a large bearing on how well the total forage productivity can be utilized. Recognizing that more than half of the growth occurs in late spring and that summers are dry, with resulting low forage quality, the opportunity exists to tailor a fit between animal and forage.

First, some hay is generally necessary and desirable for winter feeding, regardless of the kind of animal you have. Hay can be cut from pastures in late May to early June; the earlier the cut, the better the nutritive quality will be. Pastures to be reserved for hay can be grazed to about mid-April. Grazing ewes is preferable to grazing cattle when soils are wet. Weaned calves are better than cows, since calves have less potential for damaging the soil's productivity by compacting wet soils. Moderate winter grazing seems not to delay spring growth, but close winter grazing does. If an abundance of early spring forage is desired, some reduction of winter use through hay feeding will be necessary.

Try to match animal requirements and seasonal forage supplies. For cattle the best fit is with yearlings, which should go on pasture in April and come off in early July. Next are cows with fall-born calves. Wean the calves when forage dries up. The poorest fit generally is with cows with spring-born calves. Calves are just starting to grow when forage dries, so the cow's milk flow slows and the calf's growth rate is far from optimum. Some better source of summer forage, such as irrigated pasture or summer annuals, is necessary.

Ewes with January-February born lambs, especially with a high percent of twins, are well matched to the forage production pattern. Lambs can be weaned when forage dries. Ewes do well on dry summer feed. Some extra management may be desirable during breeding in early fall, since pastures normally will not yet have started their new growth.

The most difficult thing about grazing management of improved pastures is to graze them uniformly. The problem usually develops when pastures are too large. This problem is relatively easy to solve through fencing. If properly stocked, rotation of livestock from unit to unit during the spring flush will result in more overall production than set stocking, according to research studies. This is primarily because the level of use can be controlled; whereas, if continuously grazed, either underuse or overuse generally occurs.

During summer, when forage is dry, management to maintain animal performance is probably more critical than management for the plants—with one important exception. A subclover-grass pasture *must* be grazed closely enough by the onset of fall rains so that the small, emerging clover plants will have good light and not be shaded by old litter. So,

whether the pasture is rotationally used or set stocked in summer depends on the animal performance desired. Dry ewes and dry cows can be rotationally grazed to clean up the excess growth. Yearlings would already have been sold. Spring-calved cows should not be stocked heavily, or calf performance will suffer. This class of cattle is not well suited to dryland improved pasture alone.

Irrigated Pastures

Irrigation schedules should be set in relation to the species demand and the infiltration capability of the soil. For best pasture management, do not allow plant roots to dry. This means frequent, light irrigation, especially for clover-grass pastures. If a deep rooted plant such as alfalfa is the legume, heavy, infrequent watering is better. To reduce soil compaction, avoid irrigation when stock are on the pasture. However, sprinkling on light-textured soil while grazing is acceptable.

Keep vegetation at a height for optimum regrowth. To accomplish this, tight rotation grazing is a must. When growth gets ahead of the stock, either mow it or let a unit go and make hay. The important thing is—do not let forage plants become too tall. All plants attempt to reproduce, and irrigated plants have a better opportunity to do so than those under dryland conditions. Since mature plants are less palatable and nutritious, try to graze uniformly by moving stock from pasture to pasture.

The number of moves depends on the number of pastures. At least four are necessary and more are desirable. During the fast-growth period, the time between grazings will be shorter than at other times. Many irrigated pastures are grazezd 5 to 7 days and rested 14 to 21 days. This can be accomplished with four units.

Whether irrigated or dryland, well managed pastures contribute greatly to the health and productivity of your animals. Hungry livestock do not perform well. Watch both the condition of the pasture and that of the animal. Do not rely on the condition of the animal to control pasture rotation. Some of the time this will work successfully. Most of the time it will not. Therefore, closely watch the condition of the forage species and *move livestock in accordance to plant needs*. There will be a lag between the time stock should be moved to another pasture and the time their condition will show it. Animal condition is not difficult to recover when abundant nutritious forage is present. But forage plants, once depleted of energy, need time to recover. Consequently, moving stock too often or too soon will result in less total forage utilization. This is preferable to overgrazing.

Unimproved Pastures

Most livestock operators desire a highly productive seeded pasture rather than an unimproved native or weedy one. A large acreage of unimproved pasture still exists in Oregon, however, and can provide valuable forage for livestock if properly managed.

Western Oregon unimproved pastures contain relatively few desirable native perennial forage plants. Often, the bulk of the forage will be resident annuals such as soft chess, ripgut brome, annual dogtail, and rattail fescue. In some cases, weedy perennial grasses such as bentgrass, velvetgrass, or sweet vernal grass predominate. Forage production from unimproved pastures normally will be much less than from seeded and fertilized pastures. Also, much less management flexibility will exist.

Plants in unimproved pastures do not make much winter growth so they should not be grazed until weather warms considerably. In this environment, where precipitation is 20 to 50 inches, winter moisture is seldom a limiting factor. In fact, soils usually will be too wet for safe cattle grazing from December through March. Sheep do not cause as much winter damage to the plant cover as cattle.

If annual grasses make up a significant part of the forage supply, grazing fairly heavily in April and May will be necessary for most efficient utilization. After annual grasses dry up they are not only less preferred but are much less nutritious. Grazing annuals heavily is acceptable as long as the soil surface is not bare.

Pastures that contain perennials should be grazed in relation to the stage of maturity of the most important species. Plants such as bentgrass are late maturing, whereas those such as velvetgrass, are early maturing. If you wanted to increase velvetgrass, for example, late grazing would be more beneficial than earlier use. Division of pastures into smaller units will permit management for more uniform forage utilization, as compared to one large unit. This will be so whether animals are grazed rotationally or set-stocked. Consider improving pastures by seeding to more productive species when more forage is a primary objective.

Summary

Extension agents in each county will be able to give specific answers to your improvement and management questions. The general recommendations listed here should satisfy most of the pressing needs.

1. If possible, rework older pastures and introduce improved species such as subclover, perennial ryegrass, tall fescue and/or orchardgrass to increase forage production.

2. Simple mixtures of one grass and one legume usually are easier to manage than those containing more species. For example, a mixture of clover, tall fescue, and orchardgrass often will revert to fescue and clover because the orchardgrass will be preferred by the animals over fescue, and over time will not be able to compete successfully.

3. Cattle do well on more coarse, upright species than do sheep. Consider a mixture of tall fescue and subclover. Be patient while the fescue is becoming established, as it will take longer to establish than perennial ryegrass.

4. For sheep, a mixture of perennial ryegrass-subclover will not only provide high production, but sheep will be able to utilize them effectively. Orchardgrass can be used in sheep pasture. Tall fescue generally is not preferred by sheep.

5. Seed only into firm seedbeds and be certain soils have been tested and fertilized accordingly. Plant dryland pasture species before or just after first fall rains.

6. For high production in irrigated pasture, use a perennial legume such as white clover with a high producing perennial grass, tall fescue, or orchardgrass. Timing the planting is not so critical when irrigation is available to promote establishment.

7. High production requires adequate levels of available plant nutrients, especially phosphorus and sulfur for clovers. Apply P and S fertilizers in the fall before soils become damp. After several years of annual applications of P and S, levels should increase so that alternate year or even less frequent applications may be sufficient. Test soils annually fo'lowing the growing season and fertilize according to OSU fertilizer guides.

8. Have individual pastures small enough so close grazing control can be practical. Cut excess spring growth for hay rather than undergrazing.

9. Judicious management of grazing during winter should not damage overall production. When soils are wet, grazing can harm pasture stands by compaction. This is especially true when grazing cattle. Maintaining healthy, vigorous plants is the key to high forage production.

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Range and Pasture Management in Central and Eastern Oregon

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All too often, pasture and range management receive a low priority even though grazed pasture is the basis of most livestock operations. In reality, forage is the basic product you market; the best way to do that is with livestock. Overall productivity is a function of both your land resources and the intensity of the management you can give them. This circular first discusses some of the general principles of plant growth, animal preferences, and reasons for poor production. Then a section apiece is devoted to irrigated pastures, seeded dryland pastures, and native rangelands.

General Principles

Forage is often wasted in pastures because of inadequate control of animals. The most common sign of wasted forage is patch grazing—a few areas overused and much of the pasture underused. Animals will repeatedly graze regrowth in small areas and will allow other plants to reach maturity. Often more than one year's growth is accumulated, which results in very low quality forage. This can happen, and often does, even when you plant a single species in a pasture. You must match the grazing pressure to the forage supply to achieve the desired use level through intensive management.

To accomplish this, subdivide pastures into several units with fences and move stock in accordance to a plan based upon the kinds of pasture or range plants. Close control of grazing livestock is the key to correct and proper forage utilization. It may be necessary to mow periodically in the absence of sufficient grazing pressure.

Whenever possible, provide your grazing animals with what they prefer to eat. This is possible whenever planted pastures, both dryland and irrigated, are available. This may be termed *"fitting the resources to the animal."*

In this case, plant the desired species, perhaps fertilize them, irrigate if that is possible or practical, perhaps mow (or even spray) for weed control. Small-sized pastures are necessary for effective management. High forage production should be a management objective. Making good use of all that forage with your grazing animals becomes a real challenge.

In situations where pastures have not been, or cannot be, planted with other species, *fit the animals to the resources.* Match the number of animals or demand to the most opportune time for the major forage species.

Four management principles are important: (1) correct *stocking rate* for the plant species on the range or pasture unit, (2) correct *season of grazing* for those species, (3) uniform *distribution of grazing*, and (4) correct *kind* and *class* of livestock for the resources you have. Maintaining forage production through proper forage use becomes the key to successful management.

You must recognize how plants grow and what their basic needs are. Each plant species is different, but effective management schemes can be developed for numerous mixtures of species. Perennial species grow differently than annuals. Perennials are dormant after they mature. Annuals are dead. The survival mechanism of annuals is their seed. That is why, to perpetuate annuals, you need to provide for seed production. This is not required for perennials every year, except that setting seed is the signal for completion of the plants' normal growth processes. Seed is required to establish new plants of most bunchgrasses, however.

Plants must be allowed those processes. As an example, perennial grasses and forbs store food (energy) in roots and crowns and draw on that food to make new growth. Grazing at the wrong time, especially if too severe and too long, can hurt the plant by not allowing it to restore energy reserves. If continued, the plant declines in vigor. This permits other, less palatable plants to increase and outcompete the desirable grazed plants.

There is great variation in the ability of different plant species to tolerate grazing. As a general rule, most *domestic* perennial pasture species are better suited to grazing than *native* species. In order for a perennial plant to start growth, it draws on energy for new leaf growth. Depending upon the species, there is a time in the growth cycle when the plant

needs to make more energy than it uses so surplus energy accumulates in roots and crowns. The process is generally complete by the time seed has been formed.

Annual grasses and forbs develop a completely new root system every year. After germination this root system must be allowed to develop. Once the annual has a root system under it, the tops can tolerate grazing. It then becomes important to tailor the use to the amount of shoot or top growth remaining since by removing all top growth the plant will be practically dead. A perennial plant, on the other hand, already has its root system in place.

Many plants, whether perennial or annual, have an ability to tiller or "stool" out. This means additional new basal stems. Some plants tend to grow more prostrate than others. Early grazing stimulates this desirable activity. As long as grazing pressure is not too heavy and openings are not made in the plant cover, damage should not result.

Mature cattle eat upright coarse species more readily than do sheep. Young animals prefer young, green plants. They do not grow well when they are forced to consume mature plants, even generally preferred plants.

Plants contain more overall nutritive value when young than after seed heads emerge. But high moisture content in young plants can limit forage dry-matter intake. Virtually all plants in immature stages contain balanced nutrition, so grazing animals seldom need more than trace mineralized salt. Animals will always prefer regrowth of a plant to the same plant that has not previously been grazed. This is because the regrowth is younger, more succulent, and probably more nutritious plant tissue.

Ranges and pastures deteriorate because of a number of reasons. Most often part of the cause is grazing control. On irrigated pastures the reasons additionally include inadequate fertilization, poor irrigation practices, poor selection of species, incompatible mixture of plant species seeded, and permitting the plant cover to open up (which allows weed invasion and rodent infestations).

On ranges and unimproved pastures, the basic cause of deterioration is grazing-related, whether from livestock, game, rodent, or insects. Other less desirable species can invade whenever bare areas open up. Look for the correct causes for pasture or range deterioration; do not confuse symptoms with causes.

You can obtain specific recommendations on forage species, fertilization, and irrigation from your county Extension agent and Soil Conservation Service personnel. However, some management factors are relatively straightforward.

Irrigated Pastures

The cost of establishing and maintaining irrigated pastures necessitates a high level of management for sufficient return to occur. Make this commitment to the high level of management at the time you start a project. Since levels of forage production can be quite high from irrigated pastures, grazing control is extremely important. Recent studies show that three yearling steers per acre or six weaned calves per acre can be grazed over an entire growing season when proper attention is paid to the level of defoliation of the species.

Close rotation is mandatory. As much as 900 pounds of gain per acre have been reported in the cold and short growing season of the Oregon high desert. More could be obtained in other locations with longer growing seasons such as in the Treasure Valley and in the Columbia Basin.

Species Selection

The length of growing season and length of time irrigation water is available govern the species that can be planted and survive. All species must be winter hardy, but obviously a pasture in Lake County has a shorter season than one in the Columbia Basin. Simple one-grass-one-legume mixtures are more easy to manage than complex mixtures. Including a legume has two main advantages: higher forage nutritive value from a mixture of grass and legumes, and ability to fix nitrogen from the air in the soil, which will reduce the need for N fertilizer. Some species are more winter hardy than others. Very winter hardy species do not make early spring growth.

Favored grasses are orchardgrass, tall fescue, smooth brome, intermediate wheatgrass, timothy, and meadow foxtail. Each species has several varieties. White clover, birdsfoot trefoil, strawberry clover, and alfalfa are commonly planted legumes. Alfalfa for pasture requires special close rotation management, or it will decline rapidly.

Select species with an eye to their compatibility in certain attributes such as palatability, water requirement, and times of growth. Meadow foxtail and intermediate wheatgrass would be one example. The former needs and can tolerate abundant water, and the latter can get along on a short, early water supply.

Another example would be orchardgrass, tall fescue, and white clover. Whether grazed by cattle or sheep, livestock would prefer orchardgrass and white clover to tall fescue. In time, the stand would be dominantly tall fescue.

Establishment

A fine, firm, weed-free seedbed is necessary. One rule of thumb is that your heel should not sink in more than 1/2 inch when you walk across the field before planting. Visualize planting your pasture as you would your garden or a new lawn. Once the seed is planted, it is too late to do much else except irrigate. As a general rule, cultivation over 6 inches deep is not necessary. Perennial grasses have relatively deep root systems and can penetrate uncultivated soil below the plow layer.

Control of weed competition is extremely important. Whenever practical, summer fallowing before planting the pasture will help greatly as the purpose is to stimulate germination of weeds and then cultivate them out. Often, planting an interim crop that is highly competitive will be helpful in suppressing the weed potential. It will provide some needed livestock feed, too. Herbicides are available for integration into the process under special weed conditions, but this should not be necessary in most cases.

Soil from the upper 4 to 6 inches should be analyzed for available nutrients well ahead of planting time, so that you can add appropriate fertilizers and/or soil amendments. Incorporate fertilizers such as phosphorus, sulfur, and potassium into the seedbed; nitrogen can go in with the seed. If a drill with a fertilizer feeding mechanism is available, you can band all fertilizers during the drilling operation. Consult your Extension agent for specific fertilizer recommendations.

Clean seed is a must. This is determined by the percent purity as noted on the seed tag. Strive to get the cleanest, highest percent germination seed possible. Remember that desirable plants can come only from pure live seed of the

species and variety that you want. To ensure varietal purity, purchase certified seed whenever possible. Although seed prices may appear expensive, the seed cost per acre is relatively minor compared to cultural and fertilization costs.

Seeding conditions and seeding rates are both important. A good rule of thumb is to plant just deep enough so all seeds are covered. Soil should be firm both beneath the seed and above it. Only when soil is in close contact with seed will it have the opportunity to germinate rapidly and evenly. When soil is firm around seed, capillary action will allow existing soil moisture its maximum chance to provide germination conditions. And when rain does come or irrigation is applied, it will be more effective with close soil contact.

Increase the rate of seeding if the recommended conditions are not possible. For example, when seed cannot be drilled precisely and must be planted either with poor equipment or broadcast and then covered, increasing seeding rate by 50% above the minimum needed for a stand is warranted. Or when severe soil conditions exist (such as might occur with heavy clays or light sands), increase the seeding rate. When you want a dense stand quickly, more seed also is necessary. However, for most pasture species, there will be five or more seeds per square foot if only 1 pound per acre is planted. Local technicians should be consulted for recommended seeding rates.

Time of seeding is important. Spring planting is usually preferable, although planting in summer or early fall is done also. Avoid planting irrigated pastures too near to winter cold conditions. New plants need to become somewhat "hardened off" before winter sets in. Generally, 8 to 10 weeks before anticipated cold that will stop plant growth will be sufficient.

Inoculate legume seeds with an approved inoculant before seeding. This is cheap insurance. Be sure the inoculant you buy is not outdated and has been kept cool in storage. Host-specific Rhizobia applied to the seed invade the small new roots and cause the plant to form nodules. These bacteria have the ability to extract nitrogen from the air in the soil and incorporate it into the plant—in essence, making it nitrogen- or protein-rich.

As the roots die, the nitrogen within the soil system becomes available to all plants. If legumes do not become well nodulated, their productivity is sharply reduced; quite often, they do not establish if not nodulated. Many soils have adequate supplies of the right bacteria; but if the legume has not been grown previously in the soil, inoculation will be the only source of bacteria.

Fertilization After Establishment

The primary need will be for nitrogen (N). The amount of N to use will depend on the kind of species present, the amount of growth response desired, and the overall cost to obtain a particular response. Applying nitrogen fertilizer several times during the growing season before irrigations is preferable to one large application. This will result in more uniform forage production rather than one large flush of growth with a tailing-off effect. Newly established pastures economically respond to 100 to 120 pounds N/acre. Older pastures with much Kentucky bluegrass and/or quackgrass will require 50 to 60 pounds N/acre. Consult OSU *Fertilizer Guides* 21 and 38 (eastern and central Oregon, respectively).

Irrigation

Set irrigation schedules in relation to the species demand and the infiltration capability of the soil. Optimally, plant roots should never be dry, which would mean frequent light irrigation. For clover-grass pastures this is preferable, But if alfalfa is the legume, heavy infrequent watering is better. Whenever possible, avoid irrigation when stock are on the pasture. However, sprinkling on light-textured soil while grazing is acceptable.

Grazing

Proper grazing will have more to do with maintaining high pasture production than any other single factor. Do not graze new pastures until the plants are well established. Development of a deep, healthy root system is necessary. This should be by the first fall season. Often, a new stand will be mowed during its first season of growth to control weeds and keep the planted species in a vegetative state. Sheep may be grazed earlier on a new stand than cattle because of less grazing and trampling damage.

Keeping vegetation at a height for optimum regrowth is critical. Thus, tight rotation grazing is a must. When growth gets ahead of the stock, either mow it or let a unit go and make hay. The important thing is—do not let forage plants become too tall. All plants attempt to reproduce; irrigated plants have better opportunities than those under dryland conditions. Mature plants are less palatable and nutritious. So graze uniformly and move from pasture to pasture.

The number of moves depends on the number of pastures. At least four are necessary, and more will be desirable. During the fast growth period, the time between grazings will be shorter than at other times. Many irrigated pastures are grazed 5 to 7 days and rested 15 to 21 days. You could accomplish this with four units.

Well managed pastures contribute positively to the health and productivity of your animals. Hungry livestock do not perform well. Watch both the condition of the pasture and that of the animal. Do not rely on the condition of the animal alone to control pasture rotation. Some of the time, this will work successfully. Most of the time, it will not. Therefore, closely watch the condition of the forage species and move livestock in accordance to plant needs. There will be a time lag between the time you should move stock to another pasture and the time their condition will show it.

Animal condition is not difficult to recover when abundant nutritious forage is present. But forage plants, once depleted of energy, need time to recover. Consequently, moving stock too often or too soon will simply result in less total use and will be preferable to overgrazing.

Seeded Dryland Pastures

Unless soils will not permit it, planting improved species will result in greater forage production and forage more tolerant to grazing pressure than leaving a pasture in native species. Production is related strongly to amount of precipitation, but 1000 or more pounds of forage per acre can be obtained on many dryland sites. With some species, this is 1 or more animal unit months per acre.

Plant Species Selection

Fewer species are adapted to any particular dryland site than if that same site were irrigated. Essentially, you must answer two questions: (1) What is the site adaptability? Will the plants grow and reproduce? (2) What are the uses you will make of the forage? Answers to number 1 can limit answers to number 2.

Wheatgrasses such as crested, pubescent, intermediate, and tall wheatgrass, together with other species such as big bluegrass and alfalfa are most commonly used. If you live where 18 or more inches of precipitation occur annually, you can add smooth brome and tall fescue to this list.

In forested, cooler sites, orchardgrass and timothy will produce well above 18 inches. In alkaline soils, tall wheatgrass may be the only species to survive. All of these species are winter hardy. Growth starts in March-April and will contin[illegible] until moisture supplies cease.

Site Preparation

Usually, you will have to face two main decisions: (1) What is the most effective way to control the brush, trees, or weeds? (2) What level of seedbed preparation will I need? Since so many different situations exist, this circular can address only a few generalizations.

First, examine the potential for the site being considered. Are soils deep and stable enough to provide high forage production? Are there some soil conditions that warrant special consideration (rocks, clay content, alkalinity)? Can stock water be readily supplied so the seeding may receive the intensive management needed?

Consider the nature of the brush, tree, or weed problem. In some circumstances, prescribed burning may be the cheapest and most effective way to clear the area; but if plants such as the sprouting rabbitbrushes are present, fire would only allow it to increase. If cultivation is necessary for the seedbed, anyhow (often it is not—for example, after a fire, as long as a rangeland drill is used to plant seed), consider summer fallowing the site. Early cultivation will reduce the weed seed supply. Perhaps a herbicide could be effectively used to control the weeds and a range drill to plant seed.

Taken all together, several approaches may be possible: fire, herbicides, rotary mowing, followed by either a range drill or cultivation and then planting. Perhaps the ma[illegible] limiting factor is type of equipment available. Whatever the case, understand the nature of the competitive plants you must control. Clearing the site is a critically important step in the process to minimize reestablishment of weedy species.

Establishment

Refer back to the discussion under "Irrigated Pastures" and try to get as close to those conditions as possible. Shallow seedbeds are all that are necessary, if in fact a seedbed is prepared. A form of miniseedbed is made by a range drill. It has large discs that open a furrow into which seed is dropped and then covered with a chain or pipe.

Generally, fertilization at planting time may not be desirable since moisture can be extremely limiting, and small seedlings can be "burned" at even fairly low fertilizer rates. Consult your Extension agent for specific fertilizer recommendations.

Broadcast seeding is not recommended unless there is no possibility of using a drill. Successful establishment of a dryland seeding is risky enough without just spreading seed on top of the soil, perhaps brushing it in and expecting it to grow.

Time of seeding is important. Plant dryland pastures in either late fall or early spring. The purpose is to achieve early spring germination; so if you choose fall, plant late enough so seed won't emerge until spring.

Soil conditions can influence time of seeding. Seed hea[illegible] clays only in spring after frost incidence is minimal, as frost heaving will greatly damage and kill seedlings that emerge from either fall or too early spring seedings. Conversely, on very light soils, fall is preferable to spring since moisture

evaporates quickly and spring cultivation increases evaporation. The Soil Conservation Service will have technical information on your soil type.

Grazing

Do not graze new pastures until the plants are well established. One growing season should provide this opportunity. You could graze plants, but not too heavily, the first fall season. If in doubt, do not graze until the second year, and perhaps even then not until summer if conditions for both years have been abnormally dry. Development of a deep, healthy root system is necessary.

One exception exists to this delayed grazing recommendation: if excessive competition from annuals such as cheatgrass develops in the first growing season. In this case, close *short-duration* (1 week or less) grazing in early spring will be beneficial. The newly emerging perennials will be trampled, but grazing the competition when it is palatable will be beneficial. Be certain to remove all stock so remaining soil moisture can be used by the new plants. Seeded dryland pastures generally are best suited for spring grazing. If managed correctly, they can carry livestock from spring through fall.

To successfully accomplish this, practice rotational grazing so all forage will be consumed. Continually grazing a pasture from spring to fall will result in patchy grazing. You need to recognize that forage quality of seeded pastures also declines from spring to fall as does forage occurring on native ranges. For example, crested wheatgrass provides high quality forage from early May through June and again in the fall if sufficient precipitation occurs for regrowth to take place. During summer the forage will be less palatable and nutritious, and animal gains will not be as great as in spring. If crested wheatgrass should be your only forage available from spring through fall, a rotational grazing scheme is preferable to season-long grazing, to obtain more uniform use of forage.

Some species retain their apparent palatability later into the growing season. Intermediate wheatgrass, smooth bromegrass, and big bluegrass possess this attribute. However, big bluegrass can generally grow on a drier site than intermediate wheatgrass, which, in turn, has a lower moisture requirement than smooth bromegrass. Where moisture conditions permit, it is desirable to establish separate pastures of separate species and graze these in sequence through the season. Plants will not make growth without water, so little summer growth could be expected. However, as long as grazing is managed so plant vigor is not reduced, spring-summer-fall use can well be accommodated with seeded species.

Unimproved Pastures and Rangeland

These types of pastures are usually not fertilized, are not as intensively managed as seeded ones, and are not as productive as seeded ones. Of great importance is that the most desirable native forage plants respond differently to grazing than do many of the seeded species.

Probably the unimproved range/pasture will have some undesirable plants, often shrubs. Except in the higher mountains, precipitation will be from about 10 to perhaps 18 inches. Assuming that you cannot replace the pasture species with domestic forage plants because the site is too rocky or steep, your main option is to capitalize on the inherent soil productivity.

If most of the native species are gone, management to encourage their return is essentially futile. If some of the desirable native species exist, they need to be favored. You can do this by grazing when they will least likely be reduced in vigor, allowing them a competitive advantage over less desirable plants. This, in general terms, would be early in the season for a *short time* to remove the annuals. Be certain to do this before the soil moisture is gone. The good plants must have soil moisture to grow and hold their own against the annuals and poor perennials. Of course, the stock will eat the good plants during this period, too. But by grazing uniformly for a short time period, a balance can be tipped in favor of the good plants.

Then, after soils have dried and plants are approaching maturity, grazing at even heavy rates will not be detrimental. It is usually during midseason, about the boot to early dough stage, that native perennial plants, especially grasses, can be damaged if grazed too closely. They don't get a chance to recover because remaining soil moisture is too low. When that does happen, stay off that pasture the next year until plant maturity. This is call "deferred grazing." This will give a plant that might get hurt in one year the maximum chance to recover the next year.

If the pasture is weedy and there are some good plants interspersed in the weeds, chemical weed control could be effective in reducing competition. Available herbicides are numerous. A combination of the correct herbicide, appropriate nonuse, and then proper grazing timed to use the remaining competitive plants first, will probably be the most effective procedure. By a combination of short-duration early use and late use, competing vegetation will be consumed. The good plants should recover and perhaps set seed. Stock may plant some of the seed for next year's new seedlings to replace weeds.

In dry environments, avoid grazing these native plants at the critical times or stages of plant growth in succeeding years. As pointed out earlier, plants are more susceptible to damage from defoliation in some stages than others. By rotating the use from pasture to pasture among years, the plants will have the best opportunity either to increase their vigor or to maintain it.

Summary

Healthy, vigorous plants, whether introduced or native, are vital for good pasture/range and animal productivity. Maintaining plant health is necessary for them to survive the rigors of an often unfavorable environment. General recommendations have been made. Contact your Extension agent if you need specific details.

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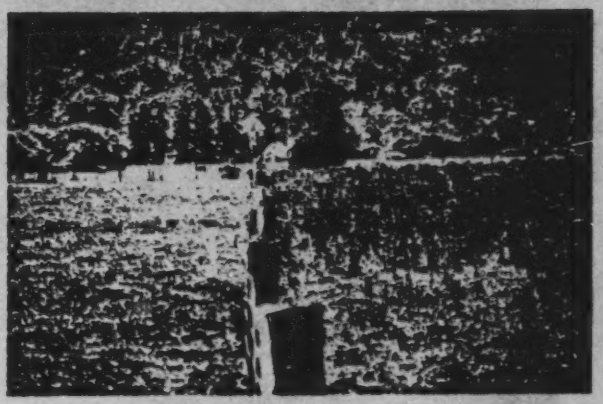
Pasture Management for Control of Tansy Ragwort

The right combination of plant species, fertility, and grazing is essential in good pasture management. Weed control also is important. Because of the toxic properties of the weed tansy ragwort, pasture management for its control is of extreme importance. The toxins in this weed can kill domestic livestock, although sheep are tolerant to large dosages.

Tansy ragwort is estimated to occur on 3¼ million acres in western Oregon, where 2 out of every 5 acres of pasture are infested. More than 112,000 acres of pasture in western Washington contain ragwort. Tansy ragwort has been reported in Idaho and is considered a serious potential weed problem that has not yet reached a level of economic importance. Most ragwort is on forested and clearcut lands. The plant spreads by seed, and grows and reproduces rapidly when pastures are not well managed. Livestock producers, part-time producers, and horse owners need to learn to control tansy ragwort to stay in production.

Plant growth

Tansy ragwort *(Senecio jacobaea)* was first reported in Oregon in 1922 after introduction into the United States from Europe. It is found in drier regions of Europe, Asia, and Siberia, where it can survive temperatures of –20°F or lower. Tansy ragwort has spread across western Oregon and Washington. Plants can withstand large variations in soil moisture conditions and will tolerate the hot, dry summers of eastern



Oregon and Washington, where it has been found in numerous locations. It is believed to be capable of establishing itself throughout the Pacific Northwest. Tansy ragwort can become established rapidly in forest clearcuts and can develop in irrigated, nonirrigated, and woodland pastures. It occasionally occurs in annually tilled cropland. The heaviest infestations now occur in the coast range.

Tansy ragwort has conspicuous, daisy-like golden flowers, which appear over an extended period. The rosette has irregular, lobed leaves, 5 to 9 inches long,

Tansy ragwort leaves and the blade region near the tip are deeply lobed. Leaf color varies from light to dark green.

In the pasture complex, livestock often cannot separate the rosette stage of tansy ragwort from desirable forage.

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Always follow label instructions of the product being used. Read the label carefully for grazing restrictions before applying any herbicide. *Note:* Application of 2,4-D may injure clovers. Dicamba will kill clovers.

Biological control

Larvae of the cinnabar moth can reduce tansy ragwort populations to low levels in areas where other controls are not practical or economical.

The adult cinnabar moth is normally seen from April to July.

Insects are considered primary bio-control agents, but proper use of sheep grazing is also a form of biological control. Plant diseases may play an important role in the future, but presently there are no specific diseases used to control tansy ragwort.

The cinnabar moth, *Tyria jacobaeae*, was introduced into the Pacific Northwest in 1960 and is now widespread throughout the ragwort-infested areas west of the Cascade mountains. Cinnabar larvae feed on the foliage and flowers of ragwort, and in large numbers can totally defoliate the plant. Although the insect is widespread, not all areas have colonies. The following will aid in collection and successful establishment of cinnabar larvae from established colonies to new sites. The larvae should be nearing maturity, at which time they will be about 1 inch in length. Mature larvae are usually available from late June through July. An easy method to collect larvae from ragwort is by simply tapping the flowerheads into a large grocery bag, since the larvae readily fall when disturbed. Some ragwort foliage and stems should be placed in the bag as a source of food while in transit, and the bag should be kept shaded and cool until the larvae are released.

The new release site should have ample ragwort to support the larvae; however extensive stands are not necessary. Dump the larvae on flower clusters at the new site, but do not disperse them too widely. Do not be concerned if they fall to the ground. They will relocate tansy ragwort plants rapidly. In a dense stand of ragwort, 1,000 larvae could be released on an area of 200 square feet. The site should be well drained and should not be subject to winter flooding, since the insect overwinters as a pupa (cocoon) in litter on the soil and will drown on wet or soggy sites. The

The adult flea beetle is a new addition in biological control of tansy ragwort.

site should not be heavily grazed, as livestock trampling can destroy overwintering pupae. The cinnabar moth can be used where grazing occurs, but a protected site within the grazed area, such as a fence row or brush patch, should be chosen to protect the initial larval release. If larvae are not available for collection, consult your Extension agent or county weed control supervisor, as most counties are actively involved in the cinnabar moth program.

Even the severe defoliation by cinnabar larvae often does not kill ragwort. During late August and September, after the cinnabar larvae have formed pupae, rag-

attached directly to the main stalk. Plant color is variable, ranging from light to dark green.

Tansy ragwort is a biennial, but can develop as a short-lived perennial. Seeds can germinate in the fall or spring. The vegetative stage is a low, dense, rosette. Plants that emerge early in the fall and develop a rosette before winter usually bloom during the following summer, produce seeds, and die. Plants that emerge late in the fall or in the spring are more likely to remain vegetative during the summer and bloom during the second summer. If the plant is cut or broken before it blossoms, it may regrow and flower during the third year.

Seed is the primary method of ragwort dispersal. It is spread by wind, water, and animals, including humans. Transportation of contaminated hay and straw from western Oregon and Washington by hunters is a major cause of movement east of the Cascade Mountains. A single plant may produce 150 thousand seeds, which can remain viable in the soil for 3 years or longer. Most seeds do not move more than a few feet from the parent plant.

Toxic properties

Livestock normally will not graze tansy ragwort if more desirable forage is available. Small plants, growing in intimate association with grasses and clovers or plants that may occur in hay, cannot be excluded selectively. Second-year plants are not grazed by horses and cattle until all other preferred forage has been removed.

Tansy ragwort contains at least six pyrrolizidine alkaloids. Concentration of alkaloids is greatest in flowers, then leaves, roots, and stems, and averages about 0.18 percent of the dry weight. The alkaloids themselves are not toxic. In the presence of certain liver enzymes, however, pyrrolizidine alkaloids are converted to pyrroles. When enough conversion to pyrrole has occurred, the liver ceases to function normally and the animal dies. The liver damage is cumulative with time and dose.

Cattle and horses are affected seriously; goats may suffer poisoning; sheep are generally not poisoned by tansy ragwort. Experiments show that dry tansy ragwort (weighing 2 percent of a weaned calf's body weight) fed over a 15- to 30-day period is enough to kill the animal. The toxic effect persists even when animals are removed from tansy ragwort after exposure. In the experiments this amounted to only 7 percent of the daily food intake. Ragwort fed to goats at 1 percent of their body weight for 25 days, during lactation (for a total of 125 percent of the goat's body weight), caused abortions and subsequent death of the does. It is unlikely an animal could graze that much on its own, since it represents about one-third of normal daily needs. Pyrrolizidine alkaloids have been found in milk from cows and goats fed a diet containing tansy ragwort. Susceptibility to tansy ragwort poisoning varies greatly among individual animals. Livestock in poor body condition are most rapidly affected because of pre-existing liver conditions.

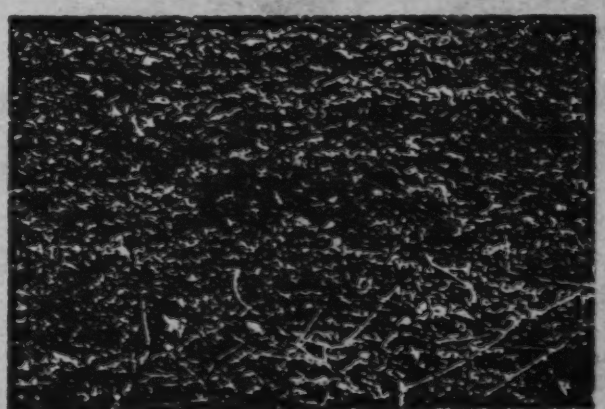
Sheep are not easily poisoned by tansy ragwort. Ragwort is not rejected by sheep as it is by cattle and horses. Sheep may graze green ragwort plants preferentially in summer when other plants are dry. The leaves of tansy ragwort contain in excess of 10 percent crude protein and flowers contain 14.5 percent. In experiments, sheep have eaten more than twice their body weight in tansy ragwort and demonstrated no evidence of toxicity. Cattle are poisoned after ingesting 2 to 8 percent of their body weight. Younger animals are most sensitive. Sheep apparently do not convert pyrrolizidine alkaloids to pyrroles in their livers. It is not known whether sheep reconvert pyrrolizidine alkaloids into new molecules in the rumen or whether they don't have the liver enzymes to convert them into the toxic form. The OSU School of Veterinary Medicine offers blood enzyme tests for cattle, horses, and sheep. The tests can determine relative levels of toxin accumulation.

Costs of no control

Everything has a price tag. Inadequate pasture management is no exception. Losses from reduced performance of unthrifty animals and dead animals are real, as is competition by tansy ragwort for space, moisture, and nutrients. Dense populations of ragwort may reduce forage yields by 50 percent or more. The "cost" of anxiety when family horses are involved cannot be measured.

Cultural management

In a poorly managed, ragwort-infested pasture, the potential for damage to cattle is high.



Cattle will graze tansy ragwort in poorly managed pastures where other forage is limited.

The incidence of tansy ragwort is lower on well-managed pastures. The following practices are suggested to keep plants from setting viable seeds and to help achieve and maintain high forage productivity.

• Plant improved, high-yielding pasture species. Pastures with subclover or white clover and perennial grasses produce three to five times more forage, of higher quality, than native or annual grass pastures. Vigorous plants also provide more competition to tansy ragwort.

• Fertilize according to soil needs. Clovers require phosphorus and sulfur primarily; grass needs nitrogen. Clover can provide nitrogen through nitrogen fixation, but phosphorus, sulfur, and several other nutrients must be provided through chemical fertilizers or manure. Test soil to determine phosphorus needs. Consult OSU Fertilizer Guides 1, 2, and 63 or WSU Fertilizer Guides 1, 16, and 20. Instructions and sampling containers are available at county Extension offices.

• Maintain a dense stand. Tansy ragwort seed can germinate and establish in "holes" or "broken" spots in the stand more easily than in dense growth. Establish a good stand in the beginning. For example, tansy ragwort is seldom found in tall fescue growing in highway rights-of-way.

• Graze uniformly. Good grazing programs stimulate good plants to be more competitive and promote a higher proportion of clover. Subdivide pastures with fences and move stock from unit to unit in a planned sequence to avoid overgrazing.

• Avoid winter grazing by cattle and horses and grazing during irrigation. Large animals open "holes" in a good grass-clover pasture when soils are wet. Some winter use of excess grass growth by sheep or light cattle allows more light to reach the lower-growing clover and stimulates tillering of grass.

• Maintain a balance between grass and clover species. A proper forage mixture extends seasonal production, increases total productivity, and extends duration of competition to invading ragwort plants.

If tansy ragwort is already a problem in pasture, consider the reasons it became a problem. It is possible that some management practices promoted establishment. If preferential grazing is initiated too early in the life of the pasture stand, the soil disturbance may cause ragwort to develop from seed. Grazing either after new plants were firmly established or when everything was green should have minimized the invasion.

Continuous sheep grazing will remove tansy ragwort and keep it out. Observations suggest that the control occurs by keeping the plants from going to seed. Constant grazing may keep a plant vegetative and allow a second-year plant to develop into the third year. If not grazed, third-year plants will flower before they die. If sheep are removed and a seed source is present, tansy ragwort will reinfest the area. Mixed grazing by cattle and sheep results in more uniform forage utilization. Sheep can be used as a "preconditioning" agent ahead of cattle. Graze sheep from May to early June at an intensity that forces them to consume all tansy ragwort plants. This prevents ragwort plants from setting seed. Intense grazing for 2 to 3 years in sequence will reduce tansy ragwort populations so that cattle could be grazed safely during the growing season. Remove cattle if young tansy ragwort is being eaten.

Mowing is not effective in reducing tansy ragwort populations. Theoretically, mowing should keep plants from blooming if clipping is properly timed. In practice, this is virtually impossible to achieve.

Hand pulling and digging can be an effective tool in keeping second-year plants from setting seed. If plants start to bloom some viable seed can be produced. Hand labor requires persistence and intensive effort and is most applicable to spot infestations or small acreages. Unless the entire root system is removed, however, regrowth frequently occurs from segments left in the soil.

Chemical control

Tansy ragwort was controlled in test plots using 2,4-D applied at the rosette stage.

Effective and economical control of tansy ragwort has been accomplished with 2,4-D. Application is made during the early spring (April) or midfall, after rains have initiated new growth. Use amine, low-volatile ester (LVE), or emulsifiable acid forms of 2,4-D when ragwort is small or in the rosette stage. Apply 2 pounds acid equivalent per acre. If the 2,4-D formulation is 4 pounds-per-gallon use 2 quarts per acre in 20 gallons or more water. When applications are correctly timed, 2,4-D amine without wetting agent at 2 pounds per acre has given good to excellent ragwort control with minimum clover injury. Fall applications cause less clover injury than spring treatments.

If tansy ragwort is more mature and has a large rosette or the flowering stalk has elongated, use dicamba (Banvel) or dicamba – 2,4-D. Apply 1 pound active (1 quart) of dicamba or 0.5 to 1 pound dicamba plus 2 pounds (2 quarts) of 2,4-D per acre. Apply in 20 or more gallons of water.

After plants have bolted and developed a seedstalk, control with 2,4-D is less effective. The addition of dicamba results in increased control of mature plants and is effective in stopping the development of seeds in the flower. For best results from spot treatment, wet plants until spray begins to drip. Make application on a warm sunny day. Spray when no rain is expected for a minimum of 6 hours. After treatment, plants die slowly.

OREGON STATE UNIVERSITY EXTENSION SERVICE

Oregon State University Fertilizer Guide for

Extension Service, Oregon State University, Henry A. Wadsworth, director. This publication was produced and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. Extension work is a cooperative program of Oregon State University, the U.S. Department of Agriculture, and Oregon counties. Extension invites participation in its programs and offers them equally to all people.

FG 16
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PERENNIAL GRASS PASTURE
(Non-Irrigated)
(Western Oregon - West of Cascades)

Under some conditions, perennial grasses are planted for pasture, hay, and silage on many farms in western Oregon. Tall fescue, perennial rye, and orchardgrass are the most productive species. Perennial rye and tall fescue pastures on well-drained hill soils provide late winter and early spring sheep pastures.

Non-irrigated pasture production in western Oregon can frequently be enhanced through the *inclusion of a legume such as subclover in the seeding*. Fertilizer suggestions for subclover-grass pastures are contained in FG 4 which is available from your County Extension Agent.

The optimum response of grass pasture to fertilization is dependent on good management including:

1. Maintenance of a vigorous stand of improved grasses.
2. Use of good grazing management practices.
3. Avoiding soil compaction by not grazing when surface soil is saturated with water.
4. Control of weeds and other pests.
5. Using recommended seeding methods, rates, mixtures, and varieties.

It is important that the soil be sampled and tested as a guide to fertilization. Follow recommended soil sampling procedures to insure obtaining a satisfactory soil sample. Your County Extension Agent can provide you with instructions on correct soil sampling.

NITROGEN (N)

N is the plant nutrient most frequently required in the fertilization of grass forage in western Oregon.

New Seedings

Band 20-30 lbs N/A - and where required, phosphate and/or potash 1 to 2 inches below seed. At least 1 inch of soil should separate the seed and fertilizer. Where N cannot be banded, broadcast 40-50 lbs N/A at planting time.

Late winter and early spring pasture

Apply 30 to 40 lbs N/A during September. From 1000 to 1500 additional pounds per acre (dry weight) of forage should be produced from the addition of 30 to 40 pounds of nitrogen per acre if pastures reach a height of 10 inches before grazing starts. Graze these pastures or cut hay or silage by early June. On dry years utilization should be stopped by May 15. Heavy grazing after growth starts in the fall will reduce the expected early spring yield increase from fertilizer.

Grazing should not start until the grass reaches a height of 6 to 10 inches. Growing conditions during the winter will determine the date to start grazing.

Late spring pasture, hay, or silage

Apply 40 to 60 pounds of nitrogen per acre by March 1. Do not graze until pastures reach a height of 6 to 10 inches. This fertilizer application should increase the yield by 1,500 to 2,000 pounds of dry matter per acre if grazing is delayed until after grass reaches a height of 10 inches.

Late summer pastures

Poorly drained areas and deep (3½ feet plus) well-drained soils with the proper species will produce good pasture for July and August if properly managed. Apply 50 to 60 pounds of N/A between March 1 and April 15 or after the excess moisture has started to drain out of the soil. Graze or cut silage between May 1 and 15. Leave a stubble height of at least 3 inches. This stubble height is essential for summer regrowth. Heavy utilization during early May is essential to keep the grass from going to seed and becoming over mature during late June or early July.

PHOSPHORUS (P)

Soil testing should be used to evaluate the need for P fertilization.

On new seedings, when the OSU soil test for P is below 15 ppm, band 30 lbs P_2O_5/A 1 to 2 inches below the seed. *At least 1 inch of soil should separate the seed and fertilizer.* The application rate should be doubled when P is broadcast rather than banded.

On established stands, *P should be broadcast in the fall.*

If OSU soil test for P reads (ppm):	Apply this amount of phosphorus (P_2O_5)-lbs/A
0-10	40-60
10-15	30-40
	None in southwest Oregon
Over 15	None

POTASSIUM (K)

Soil testing should be used to evaluate the need for K fertilization.

On new seedings, when the OSU soil test for K is below 100 ppm, band 20 lbs K_2O/A 1 to 2 inches below the seed. *At least 1 inch of soil should separate the seed and fertilizer.* The K application rate should be increased by 50% where K is broadcast.

On established stands, *K should be broadcast in the fall.*

If the OSU soil test for K reads (ppm):	Apply this amount of potassium (K_2O)-(lbs/A)
0 to 100	60
over 100	none

SULFUR (S)

Plants absorb S in the form of sulfate. Fertilizer materials supply S in the form of sulfate and elemental S. Elemental S must convert to sulfate in the soil before the S becomes available to plants. The conversion of elemental S to sulfate is usually rapid for fine ground (less than 40 mesh) material in warm moist soil. *The S requirements of grass pasture can be provided by:*

1. The annual application of 10-15 lbs S/A in the form of sulfate or as fine ground (finer than 40 mesh) elemental S. Elemental S will not be available to plants until the soil warms up.
2. Applying 30-40 lbs S/A as sulfate or fine ground elemental S every second year.
3. Applying coarser ground elemental S at higher rates and less frequently.

Elemental S has an acidifying effect on the soil.

Responses to S fertilization may not occur for a period of at least 4 or 5 years on "red hill" soils which have a history of high S fertilization. These soils have a comparatively high ability to adsorb S and frequently have a history of high S fertilization through the use of S-containing fertilizer such as ammonium sulfate.

OTHER NUTRIENTS

Responses of grass pasture to nutrients other than those discussed in this guide have not been observed in western Oregon.

LIME

Grass pasture has a moderately high tolerance to soil acidity. A lime application is suggested if the soil pH is below 5.4 or the calcium soil test is below 3.0 meq Ca/100 grams of soil.

If the OSU SMP Buffer test for lime reads:	Apply this amount of lime (T/A):
below 5.3	3-4
5.3-5.6	2-3
5.6-5.9	1-3
over 5.9	0

The liming rate is based on 100 score lime. Lime reacts slowly in the soil and should be applied well in advance of seeding and disced into the soil. *A lime application is effective over several years.* Broadcasting lime on established stands of perennial grasses is not as effective as mixing lime with the soil. The surface application of lime to established fields could increase the soil pH in the surface one-half inch of soil and thereby increase the possibility of N loss from ammonium-N and urea due to volatilization.

The use of N fertilizers containing ammonium or urea will tend to increase soil acidity (decrease soil pH). Elemental S also has an acidifying effect on soil. Evaluate the soil acidity problem when renovating or making new plantings. The lime application should allow for some decrease in soil pH during the life of a perennial stand of grass. For soils needing lime which are low in Mg (less than 0.5 meq Mg/100 g of soil) one ton/A of *dolomite lime can be used as a Mg source.* Dolomite and ground limestone have about the same ability to neutralize soil acidity. Fertilizer Guide #3, Liming Materials for Oregon, which is available from your local OSU Extension Office, provides additional information on lime.

MANURE

Manure is a good source of plant nutrients for grass. Manures contain variable amounts of all plant nutrients. All of the nutrients in manure are not completely available the first year. The following table gives the approximate average content of some nutrients in fresh manures:

Nutrient Content of Fresh Manures

Kind of Manure	Nutrient & Water Content %			
	Water	N[1/]	P_2O_5	K_2O
Dairy	87	0.5	0.16	0.44
Beef	82	0.65	0.43	0.53
Poultry	73	0.30	1.02	0.50
Hog	84	0.45	0.27	0.40
Sheep	73	1.00	0.36	1.00
Horse	60	0.70	0.25	0.60

[1/] About 50% of the N is available the first year.

Losses of N sometimes exceeding 50% can occur during manure storage or following application to the surface of soil. N loss is least when fresh manure is spread and worked into the soil immediately. Manure can contain viable weed seeds.

The P, K, and lime suggestions are based on soil test values from the Soil Testing Laboratory, OSU, Corvallis, Oregon.

This guide to fertilization is based on fertilizer experiments conducted on grass pasture and grass seed crops in western Oregon by T. L. Jackson, and John Yungen, Oregon Agricultural Experiment Station and Lynn Cannon, Gale Gingrich, Gary Schneider, and E. Hugh Gardner, OSU Extension Service.

Prepared by E. Hugh Gardner, T. L. Jackson, W. S. McGuire, and T. E. Bedell, Oregon State University Extension Service and Agricultural Experiment Station. Reviewed by a committee of western Oregon County Extension Agents.

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FG 1
Revised June 1977

Irrigated Clover-Grass Pastures

(Western Oregon)

(Excluding Coos, Curry, Jackson, Josephine counties)

This guide to fertilization is intended for grass-legume pastures using white clover varieties such as Ladino, Grasslands Huia (New Zealand), or similar varieties in combination with orchardgrass, perennial ryegrass, tall fescue, or meadow foxtail.

The optimum response of irrigated pasture to fertilization is dependent upon good management.

The following management factors are important:

1. Maintenance of a good stand of adapted, improved legumes and grasses. The stand should be approximately 40-50 % clover.

2. Adequate irrigation without over-irrigation.

3. Harvesting at 5-6" height using rotation grazing or green chop. Green chop management results in more rapid depletion of soil fertility than grazing.

4. Close grazing (to 2" height) favors clover and light grazing (to 4" height or higher) favors grass.

5. Well fertilized grass will outgrow legumes in the fall and early winter. Excessive grass growth could result in smothering the clover. Either grazing or clipping will reduce the problem.

6. Avoid soil compaction by eliminating grazing when surface soil is saturated with water.

7. Grasslands Huia (New Zealand) variety of white clover is more resistant to slug feeding than other varieties.

8. Inoculate clover seed with the correct strain of fresh inoculum immediately prior to seeding.

9. Retest the soil and adjust fertilizer applications every two years.

NITROGEN (N)

An application of 30-40 lbs N/A in late February or early March will stimulate the grass and provide early feed. Single applications of N should not exceed 40 lbs/A.

N fertilizer favors the growth of grass over that of clover. Excessive fertilization with N can result in a decrease in the clover stand.

If the legume stand is adequate, summer N applications seldom pay. An application of 30-40 lbs N/A in late August will stimulate grass growth and may provide additional fall grazing.

PHOSPHORUS (P)

Adequate fertilization with P is particularly important to the maintenance of a good stand of clover. *The need for P fertilization can be estimated from a soil test.*

On new seedings:

If OSU soil test for P reads (ppm):	Apply this amount of Phosphate (P_2O_5)-(lbs/A):
0-10	100-120
10-20	70-100
20-30	40-70
Over 30	None

P can be applied most effectively by *banding* 1 to 2" to the side or below the seed when seeding. Some soil should separate seed from fertilizer.

Do not include boron in band applications.

Working P into the surface 2" of soil during seedbed preparation is more effective than broadcasting following seeding.

On established pasture:

If OSU soil test for P reads (ppm):	Apply this amount of Phosphate (P_2O_5)-(lbs/A):
0-15	60-80
15-25	40-60
Over 25	None

On established stands the P application should be made in the fall to early spring.

On dark-colored, well drained, coastal soils mapped as Quillayute or Winema, P applications should be increased by 30% to 50%.

POTASSIUM (K)

An adequate level of available K is essential to the optimum growth of clover-grass pastures. K is particularly important to the growth of clover. Grass competes vigorously with clover in the uptake of K.

The need for K fertilization can be estimated by a soil test.

On new seedings:

K should be broadcast and worked into the seedbed prior to seeding.

If OSU soil test for K reads (ppm):	Apply this amount of Potash (K_2O)-(lbs/A):
0-125	100-150
125-200	70-100
Over 200	None - Watch soil tests for K depletion

Established Pasture

High producing pasture can cause rapid depletion of soil K. Soils should be tested frequently to determine available K levels.

Note that split applications of K are suggested.

If OSU soil test for K reads (ppm):	Apply this amount of potash (K_2O) in fall or early spring and again about July 1-(lbs/A)
0- 75	100-125
75-125	75-100
125-200	50- 75
Over 200	None - Watch soil tests for possible K depletion

Whenever K deficiency symptoms become apparent on the leaves, at least 60 lbs K_2O/A should be applied.

A K deficiency is indicated by light colored spots around the margins of the clover leaves and yellow to brown coloring of grass leaf tips. Responses to K fertilizer are often obtained before leaf deficiency symptoms are apparent.

BORON (B)

Adequate B is required by clover-grass pastures. Clovers have a higher B requirement than grass. *Too much B fertilizer can be highly toxic*; therefore, suggested rates of B application should not be exceeded and B should be evenly distributed over the field and not banded.

If OSU soil test for B reads (ppm):	Apply this amount (lbs/A) B
0-0.7	2 -3 Annually
0.7-1.0	1 1/2-2 Annually
Over 1.0	None

B and other materials should be thoroughly mixed when B application is combined with other fertilizers.

B should be applied in fall or early spring.

SULFUR (S)

Plants absorb S in the form of sulfate. Fertilizer materials supply S in the form of sulfate and elemental S.

Elemental S must convert to sulfate in the soil before the S becomes available to plants. The conversion of elemental S to sulfate is usually rapid for finely ground (less than 40 mesh) material in warm moist soil.

The S requirements of pasture can be provided by:

1. The annual application of 15-20 lbs S/A in the form of sulfate or as finely ground (finer than 40 mesh) elemental S. Elemental S will not be available to plants until the soil warms up.

2. Applying 40-50 lbs S/A as sulfate or finely ground elemental S every second year.

3. Applying coarser ground elemental S at higher rates and less frequently.

S is contained in several fertilizer materials used to supply other nutrients.

MAGNESIUM (Mg)

Responses of pasture to Mg have not been observed in western Oregon. Trial applications of Mg are suggested where soil test levels are below 0.8 meq/100g soil.

Mg can be banded at 10 to 15 lbs/A at planting. Mg can also be supplied in dolomite which is a liming material that reduces soil acidity to about the same degree as ground limestone. Dolomite should be mixed into the seedbed at least several weeks in advance of seeding.

An application of dolomite will supply magnesium and reduce soil acidity for several years.

LIME

On acid soils clovers are more responsive to liming than are grasses. A lime application is suggested when the pH of the soil is below 5.8. The rate of lime application can be estimated from the following OSU SMP buffer table.

If the OSU SMP buffer test for lime reads:	Apply this amount of lime (T/A):
below 5.5	4-5
5.5-5.8	3-4
5.8-6.1	2-3
6.1-6.5	1-2
Over 6.5	0

The liming rate is based on 100-score lime. *Lime should be mixed into the seedbed at least several weeks before seeding. A lime application is effective over several years.*

Some soils may have a fairly high OSU SMP buffer value (over 6.5) and a low pH (below 5.5). This condition can be caused by the application of acidifying fertilizer. In this case the low pH value is temporary and the pH of the soil will increase as the fertilizer completes its reaction with the soil. This temporary "active" acidity from fertilizer is encountered following recent applications of most nitrogen fertilizer materials. Acidifying fertilizers also have a "long term" acidifying effect on soil which is cumulative and leads to lower OSU SMP buffer readings.

Sandy soils to which fertilizers have not been recently applied sometimes record low pH and high SMP buffer values. In such cases, a light application of lime (1 to 2 T/A) should suffice to neutralize soil acidity.

For acid soils low in Mg (less than 0.8 meq Mg/100g of soil) one ton/A of dolomite lime can be used as a Mg source. Dolomite and ground limestone have about the same ability to neutralize soil acidity.

Suggested P, K, Mg, B and lime applications are based on soil test values from the Soil Testing Laboratory, OSU, Corvallis, Oregon.

This fertilizer guide is based on experiments and field trials conducted by T. L. Jackson, M. D. Dawson, W. S. McGuire, and E. Hugh Gardner, Agricultural Experiment Station and Extension Service, Oregon State University.

Prepared by E. Hugh Gardner, T. L. Jackson, W. S. McGuire and Lester Vough, Extension Service and Agricultural Experiment Station, Oregon State University. Reviewed by a committee of western Oregon county Extension agents.

FR 38
Ag - XI - 117 March 1963

COOPERATIVE EXTENSION SERVICE
OREGON STATE UNIVERSITY
Oregon Counties and the U. S. Department of Agriculture Cooperating

Oregon State University Fertilizer Recommendation for

Irrigated Pastures
(Central Oregon)

Irrigated pastures are usually composed of a mixture of improved grasses and legumes. Maintaining a proper balance between grasses and legumes is essential to obtain maximum production.

Management is the key to production from irrigated pastures. Proper management of livestock and irrigation water can materially increase pasture production.

Nitrogen

Nitrogen has a tendency to stimulate the grassy portion of the pasture mixture. Continued use of high rates of nitrogen will have a tendency to drive the legume out of the stand.

The following fertilizer recommendations are for pastures containing an optimum balance between grasses and legumes.

1. 120 to 140 pounds of nitrogen should be applied annually.
2. Split applications of nitrogen with 40 to 60 pounds of nitrogen being applied in the fall or early spring and 60 to 80 pounds of nitrogen applied during the late spring or early summer have given better results than single applications.

Phosphorus

Legumes in a pasture mixture will usually respond to phosphorus.

1. Apply 40 to 60 pounds of P_2O_5 in the late fall or early spring when legumes in pasture need stimulation.

Sulfur

Sulfur is utilized dominantly by legumes. In only a few isolated cases has sulfur stimulated grass to any measurable degree.

1. Apply 40 to 60 pounds of sulfur in the fertilizer program.
2. Sulfur applications may be made in conjunction with other materials, but should be applied in the fall or early spring.
3. If a bloat problem develops because of excess legume growth, reduce the amount of sulfur applied.

Test First
TESTING TELLS
Then Fertilize

(OVER)

Potassium

Most soil tests from central Oregon show adequate potassium level for pasture production. When soil test levels show less than 250 pounds of K per acre, application should be made on a trial basis. The recommended rate of application is 60 pounds of K_2O per acre.

Lime

The lime requirement for the establishment of irrigated pastures in central Oregon has not been determined. Additional experimental information is needed in a few areas in Deschutes, Crook, and Jefferson counties.

Boron

The need for boron has not been established in fertilizer trials on improved pastures.

Prepared by Howard E. Cushman, Extension Soil Conservation Specialist, David P. Moore, Assistant Professor of Soils, Department of Soils, Oregon State University, and Malcolm Johnson, Superintendent, Central Oregon Experiment Station.

OREGON STATE UNIVERSITY

FG 21

Irrigated Clover-Grass Pastures

(Eastern Oregon - East of Cascades)

This guide to fertilization is intended for pastures consisting of *white clover* in combination with *orchard grass* or *tall fescue*.

The optimum response of irrigated pasture to fertilization is dependent on good management.

The following management factors are important:

1. Maintenance of a good stand of adapted, improved clovers and grasses. The stand should be approximately 40%-50% clover.
2. Adequate irrigation without over-irrigation.
3. Harvesting at 5"-8" height using rotation grazing or green chop. Green chop management results in more rapid depletion of soil fertility than grazing.
4. Close grazing (to 2" height) favors white clover and light grazing (to 4" height or higher) favors the grass.
5. Well fertilized grass will outgrow clover in the fall. Excessive grass growth could result in smothering the clover. Either grazing or clipping will reduce the problem.
6. Avoid soil compaction by eliminating grazing when surface soil is saturated with water.
7. Inoculate clover seed with the correct strain of fresh inoculum immediately prior to seeding.
8. Retest the soil and adjust fertilizer applications at least every two years.

NITROGEN (N)

N fertilizer favors the growth of grass over that of clover. Excessive fertilization with N can result in a decrease in the clover stand.

Clover-Grass Pastures

For new seedings: An application of 30 lbs N/A is suggested where adequate available N is not present in the soil.

Where the presence of residual available N in the soil is suspected because of heavy N fertilization the previous year or a previous legume crop, a soil test for N is useful in determining the N fertilizer requirement.

Should the nitrate-N level in the soil exceed 7 ppm in the surface foot, N fertilization should not be necessary.

The N fertilization of new seedings is usually not practiced in northeast Oregon.

For established stands: An application of 30-40 lbs N/A in the spring will stimulate the grass and provide early feed. Single applications of N should not exceed 40 lbs/A.

If the clover stand is adequate, summer N applications seldom pay. In some lower altitude areas, an application of 30-40 lbs N/A in late August will stimulate grass growth and may provide additional fall grazing.

Pure Grass

Productive irrigated pure grass pastures require 125-300 lbs N/A each year. N should be applied in 2 or 3 equal applications in early spring and about June 1 and August 1. The higher rates of application are suggested for lower altitude, longer growing season areas such as Ontario and Hermiston.

PHOSPHORUS (P)

The need for P can be estimated using a soil test. Adequate fertilization with P is particularly important to the maintenance of a good stand of clover.

Established Pasture

If OSU soil test for P reads (ppm):	Apply this amount (lbs/A) P_2O_5	P
0 - 5	60 - 80	26 - 35
5 - 15	40 - 60	18 - 26
over 15	none	

Broadcast P in fall or early spring.

New Seedings

If OSU soil test for P reads (ppm):	Apply this amount (lbs/A) P_2O_5	P
0 - 5	80 - 100	35 - 44
5 - 15	50 - 80	22 - 35
over 15	none	

The P content of fertilizer is expressed as the oxide (P_2O_5) on fertilizer labels. Multiply P_2O_5 by 0.44 to convert to P.

If possible, band phosphate 1/2" to 1" to the side or below seed when seeding. Some soil should separate the seed from the fertilizer.

Extension work in Agriculture and Home Economics, Lee Kolmer, director. Oregon State University and the United States Department of Agriculture cooperating. Printed and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914.

682

Do not band fertilizer which contains boron.

Pure grass does not require as much P as clover. Where the pasture consists of grass only, apply 40 lbs P_2O_5/A if the soil test reads less than 10 ppm P. When the soil test for P exceeds 10 ppm P fertilization of pure grass is not necessary.

POTASSIUM (K)

An adequate level of available K is essential to the optimum growth of clover grass pastures. K is particularly important to the growth of clover. Grass competes vigorously with clover in the uptake of K.

Most of the soils in eastern Oregon contain adequate amounts of K for pasture production. The need for K fertilization can be determined by a soil test.

High producing pasture can cause rapid depletion of soil K. Soils should be tested frequently to determine available K levels.

K can be supplied most effectively by working into the seedbed prior to planting. On established stands, K should be applied in the fall or early spring.

If OSU soil test for K reads (ppm):	Apply this amount (lbs/A) K_2O	K
0 to 75	100-120	83-100
75 to 150	50-100	41-83
over 150	none	

The K content of fertilizer is expressed as the oxide (K_2O) on fertilizer labels. Multiply K_2O by 0.83 to convert to K.

In *central Oregon* a response to K fertilizer may be obtained when soil test value exceeds 150 ppm.

SULFUR (S)

S requirements will vary with soil texture, leaching losses, and the soil parent material. Soils developed on pumice in central Oregon have a particularly high S requirement. In some cases, irrigation water contains appreciable amounts of S.

1. In *central Oregon*, 60 to 80 lbs S should be applied annually on the coarse sandy loam and loamy sand soils; 30 to 50 lbs S should be applied annually on the silt loam and finer-textured soils.
2. In *north central, south central,* and *northeast Oregon*, 15-25 lbs S/A should be applied on an annual basis. Two years' needs for S can be provided by applying double the recommended annual rate.
3. S response has not been obtained on some soils, such as the river bottom soils in Crook County and Malheur or Harney Counties and on some fields irrigated from the Columbia River.
4. S should be applied in the fall or early spring.

BORON (B)

In *central Oregon*, B responses have not been observed and B applications are not recommended at the present time.

In other areas of eastern Oregon, if the soil test for B is less than 0.50 ppm, 2 to 4 lbs B/A should be applied.

B should not be banded near to the seed.

ZINC (Zn)

Zn deficiency may occur in irrigated pastures in some instances. Where the soil test for Zn is below 0.8 ppm, apply Zn at 10 lbs/A.

Zn deficiencies are more prevalent on areas where limey subsoil has been exposed through land levelling.

MAGNESIUM AND OTHER MICRONUTRIENT ELEMENTS

Economic responses of pastures from the application of magnesium or micronutrients, except B or Zn, have not been observed in eastern Oregon.

LIME

Responses to lime have not been measured in experiments with forages in eastern Oregon.

In some fields, surface soil values below pH 6.0 cause some concern about the need for lime.

Before liming, soil samples, including subsoil samples (8"-20" depth) should be tested.

In many cases, the subsoil is more basic and the acid reaction in the surface soil can be corrected by deep plowing.

Liming rates should be based on a lime requirement soil test.

For the satisfactory growth of white clover the pH of the soil should exceed 5.6.

N, P, K, B, Zn and lime recommendations are based on soil test values from the Soil Testing Laboratory, OSU, Corvallis, Oregon.

Prepared by E. Hugh Gardner and T. L. Jackson, Department of Soil Science and W. S. McGuire and Norman Goetze, Department of Agronomic Crop Science, Extension Service and Agricultural Experiment Station, Oregon State University. Reviewed by a committee of eastern Oregon County Extension Agents.

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COOPERATIVE EXTENSION SERVICE
OREGON STATE UNIVERSITY
Oregon Counties and the U S Department of Agriculture Cooperating

Oregon State University Fertilizer Recommendation for

Native Meadows

Native meadows produce a sizable portion of the hay used for winter feed in eastern Oregon. Native meadows are composed of a mixture of rushes, sedges, grasses, and legumes. Without fertilization an average meadow will yield approximately 1 ton per acre. With proper fertilization yields can be increased by 2 to 3 tons.

Native meadows fall into three broad classifications: (1) Nevada bluegrass; (2) rush-sedge-grass; and (3) rush.

Nevada bluegrass meadows respond to applications of nitrogen. Rush-sedge-grass meadows respond to a combination of nitrogen, phosphorus, and sulfur. Rush (wire grass) meadows are usually flooded for long periods and do not respond to fertilization.

Fertilized meadows usually reach optimum hay stage earlier than unferitlized meadows. Quality and protein content of hay will be increased if fertilized meadows are harvested 10 days to 2 weeks earlier than normal.

Nitrogen

Nitrogen is the most limiting fertilizer element in meadow hay production.

1. An application of 60-80 pounds of available nitrogen annually has given the greatest economic return.
2. Higher rates of nitrogen gave some increase in yield but did not give as high a return for money expended.
3. Nitrogen should be applied in late fall or early spring.

Phosphorus

Phosphorus applied in combination with nitrogen has given increased yields on native meadows that contain a legume. It is also possible by careful fertilization and management to increase the amount of legume in the stand, resulting in better quality hay. Soil tests have proved fairly accurate for predicting phosphorus response on native meadows.

1. Apply 60-80 pounds P_2O_5 when soil tests are below 15 pounds phosphorus per acre.
2. Apply 40-60 pounds P_2O_5 when soil tests are between 15 and 25 pounds phosphorus per acre.
3. No phosphorus should be applied when soil test values are above 25 pounds per acre.
4. Phosphorus should be applied in late fall or early spring.

Test First
TESTING TELLS
Then Fertilize

(OVER)

Sulfur

Sulfur has stimulated legume growth in fertilized meadows in all areas except Harney County and a portion of Grant County.

1. 20-30 pounds of sulfur per acre should be supplied annually to the fertilization program.

2. Sulfur can usually be provided in conjunction with another fertilizer material.

3. Sulfur materials should be applied in the fall or very early spring to insure a response in the current crop.

Lime

Applications of lime have not stimulated yields of hay from native meadows in experimental trials.

Boron

Boron has been used only in a limited number of trials and has not given a significant yield response.

Prepared by Howard E. Cushman and Arthur S. King, Extension soils specialists, Oregon State University, Corvallis.

OREGON STATE UNIVERSITY EXTENSION SERVICE

IMPROVED DRYLAND PASTURE
Willamette Valley

Based on:

1. 40 acres
2. 8 AUM/acre
3. 7 year stand life
4. Labor @ $3/hour
5. 2 plow tractor @ $4.28/hour

INPUTS PER ACRE

PRODUCING YEARS	Labor Hrs.	Labor Value ($)	Machinery ($)	Other Item	Other Value ($)	Total cost ($)
Cultural Operations						
Apply fertilizer (2X)[1/]	.50	1.50	2.25	Fert.	36.00	39.75
Weed control (clip and spot spray	1.0	3.00	2.00	Spray	1.00	6.00
Other Charges						
Land taxes[2/]					7.00	7.00
Interest on land ($500 @ 8 1/2%) [3/]					42.50	42.50
Operating capital interest (10%)					5.62	5.62
General overhead					5.00	5.00
Amortized establishment cost					29.50	29.50
Cash costs			1.70		54.62	56.32
Non-cash costs		4.50	2.55		72.00	79.05
Total costs		4.50	4.25		126.62	135.37
Cost per AUM						
At 6 AUM's Yield						22.56
At 8 AUM's Yield						16.92
At 10 AUM's Yield						13.54

1/ Fertilizer: Fall -- 50# P_2O_5 per acre; 20# sulfur fall or spring
March -- 40# nitrogen per acre.

2/ Based on land assessed for farm use value.

3/ Current land values, particularly smaller acreages, may be substantially higher than noted.

These data were collected from Benton County Farmers and summarized by Jerry Nix, Extension field experience student, under the supervision of Harold Werth, Benton County Extension Agent, and Gene Nelson, Extension Farm Management Specialist.

Department of Agricultural and Resource Economics
February 1975.

ESTABLISHMENT YEAR (Fall Planting)	INPUTS PER ACRE					
	Labor		Machinery	Other		Total cost
	Hrs.	Value ($)	($)	Item	Value ($)	($)
Cultural Operations						
Plow 2-16' 1/	1.0	3.00	4.28			7.28
Disc 8' (2X) 2/	2.0	6.00	10.36			16.36
Cultipac and roll (2X) 3/	.50	1.50	2.75			4.25
Drill and band fert. 4/	.25	.75	3.89	Seed	14.00	18.64
Fertilize-broadcast 5/	.25	.75	1.13	Fert.	40.00	41.88
Lime and disc 6/	1.0	3.00	5.18	Lime	30.00	38.18
Other Charges						
Land taxes 7/					7.00	7.00
Interest on land ($500 @ 8 1/2%) 8/					42.50	42.50
Operating capital interest (10%)					12.55	12.55
General overhead					5.00	5.00
Total costs		15.00	27.59		151.05	193.64
Hay produced minus custom harvest 9/						(50.00)
Net establishment cost						143.64
Amortized establishment cost (7 yrs. @ 10%)						29.50

1/ Based on average soil not compacted.

2/ On some soils once may be sufficient.

3/ Can be omitted in some cases

4/ Seed consisted of tall fescue and a clover.

5/ Fertilizer - 250# 16-20 banded at seeding; March - 40# nitrogen per acre.

6/ Lime and fertilizer rates should be based on a soil test. Lime costs vary from zero to $60 per acre.

7/ Based on land assessed for farm use value.

8/ Current land values, particularly for smaller acreages, may be substantially higher than noted.

9/ Establishment year includes crop produced in spring following fall planting. This first crop may also be harvested by pasturing when properly managed.

OREGON STATE UNIVERSITY EXTENSION SERVICE

IMPROVED HILL-LAND PASTURES
Mid-Willamette Valley

Based on:

1. 200 acre pasture on 600 acre farm
2. 15 year life of stand
3. 50 h.p. tractor @ $5.45/hr.
4. Operators Labor $5.00/hr.

INPUTS PER ACRE

PRODUCING YEARS	Labor Hrs.	Labor Value ($)	Machinery ($)	Other Item	Other Value ($)	Total Cost ($)
Cultural Practices 1/						
Fertilize (Fall)	.1	.50	2.60	Fert.	15.00	18.10
Fertilize (Spring)	.1	.50	2.60	Fert.	12.00	15.10
Clipping	.3	1.50	2.45			3.95
Weed control	.1	.50		Mtl.	2.00	2.50
Rodent control				Mtl.	.50	.50
Fence maintenance	.1	.50		Mtl.	1.50	2.00
Other Charges						
Interest on land ($650 @ 8.5%)					55.25	55.25
Taxes (FUV)					5.00	5.00
Operating capital interest (10%)					1.95	1.95
General overhead 2/					3.00	3.00
CASH COSTS			3.05		40.95	44.00
NON-CASH COSTS		3.50	4.60		55.25	63.35
TOTAL COSTS (SUBTOTAL)		3.50	7.65		96.20	107.35
Credit for hay crop 3/						(25.00)
Amortized Establishment Cost						17.85
NET TOTAL COST						100.20
Cost per AUM @ 7 AUM's Yield 4/						14.30
Cost per AUM @ 6 AUM's Yield						16.70
Cost per AUM @ 5 AUM's Yield						20.05
Cost per AUM @ 4 AUM's Yield						25.05

1/ See your Extension Agent for specific recommendations

2/ Approximately 7% of cash costs

3/ Computed on basis of 50% area cut for hay @ 2 ton yield less cost of baling and handling.

4/ Total yield per acre = 4-7 AUM's plus equivalent of 1 ton hay.

These data were compiled by Extension Agents Hugh J. Hickerson and Tom Bedell, and Polk and Yamhill County farmers.

Department of Agricultural and Resource Economics, June 1975.

ESTABLISHMENT YEAR (Fall Planting)	INPUTS PER ACRE					
	Labor		Machinery	Other		Total Cost
	Hrs.	Value ($)	($)	Item	Value ($)	($)
Cultural Practices[1/]						
Plow	1.0	5.00	6.50			11.50
Disc & harrow (2x)	1.0	5.00	7.70			12.70
Harrow & roll (2x)	.5	2.50	3.85			6.35
Lime				Custom	36.00	36.00
Fertilize	.1	.50	1.55	Fert.	25.00	27.05
Drill	.3	1.50	3.40	Seed	13.50	18.40
Other Charges						
Interest on land ($650 @ 8.5%)[2/]					27.60	27.60
Taxes (FUV) [2/]					2.50	2.50
Operating capital interest (10%)					4.30	4.30
General overhead [3/]					6.35	6.35
CASH COSTS			9.20		87.65	96.85
NON-CASH COSTS		14.50	13.80		27.60	55.90
TOTAL COSTS		14.50	23.00		115.25	152.75
Amortized Establishment Cost (15 yrs. @ 8%, .1168)						17.85

1/ See your County Extension Agent for specific recommendations.

2/ Computed on six months establishment period by fall planting.

3/ Approximately 7% costs.

OREGON STATE UNIVERSITY EXTENSION SERVICE

IRRIGATED PASTURE
Coos County

Based on:

1. 10 acres
2. 10 year stand life
3. 14 AUM/acre
4. Labor @ $3.00/hr.
5. 55 DBHP wheel tractor @ $6.00/hr.

	INPUTS PER ACRE					
	Labor			Other		Total
PRODUCING YEARS	Hrs.	Value	Machinery	Item	Value	cost
		($)	($)		($)	($)
Fertilize (16-20-0)	.2	.60	1.50	250#	25.00	27.10
Irrigate (5x)	3.6	10.80	4.00	elect	4.50	19.30
Clipping (2x)	.4	1.20	3.00			4.20
Spot weed control	.5	1.50		mtl.	.25	1.75
Fence maintenance					2.00	2.00
Other Charges						
Interest on land ($425/acre @ 9%)					38.25	38.25
Taxes on land					7.00	7.00
Operating capital interest (9%)					1.70	1.70
General overhead					5.00	5.00
Amortized establishment cost (10 yrs. at 9%)					29.55	29.55
Cash costs		5.40	2.50		45.45	53.35
Non-cash costs		8.70	6.00		67.80	82.50
Total cost		14.10	8.50		113.25	135.85

Cost per AUM at 12 AUM's yield	11.32
Cost per AUM at 14 AUM's yield	9.70
Cost per AUM at 16 AUM's yield	8.49

These data were obtained and computed by County Agent Lynn Cannon and Farm Management Specialists in cooperation with Coos County farmers.

Department of Agricultural Economics, October 1974

ESTABLISHMENT YEAR	INPUTS PER ACRE Labor Hrs.	Labor Value	Machinery	Other Item	Other Value	Total cost
		($)	($)		($)	($)
Cultural Operations 1/						
Disc (3x)	1.0	3.00	10.00			13.00
Plowing (2x)	.6	1.80	6.00			7.80
Harrow & Roll	.2	.60	1.80			2.40
Disc & Harrow (3x)	1.0	3.00	10.00			13.00
Fertilize (16-20-0)	.2	.60	1.80	250#	25.00	27.40
Liming (custom)				1 ton	25.00	25.00
Roll	.2	.60	1.70			2.30
Drill 2/	.5	1.50	4.00	seed	20.00	25.50
Irrigate (5x)	3.0	9.00	4.00	elect	4.80	17.80
Other Charges						
Interest on land ($425/acre @ 9%)					38.25	38.25
Taxes on land					7.00	7.00
Operating capital interest (9%)					5.20	5.20
General overhead					5.00	5.00
Total establishment cost		20.10	39.30		130.25	189.65
Amortized establishment cost (10 years @ 9%)						29.55

1/ A nurse crop is often grown in the establishment year, but the additional costs of that crop are not considered here. It is assumed the value of the nurse crop removed will offset these additional costs. (Consult your county agent for specific recommendations.)

2/ Seed mix contains 8 lbs. ryegrass, 8 lbs. orchardgrass, and a clover mixture.

OREGON STATE UNIVERSITY EXTENSION SERVICE

IRRIGATED PASTURE (NON-PLOWABLE LAND)
Jackson & Josephine Counties

Based on:

1. 30 acres
2. 10 AUM/acre
3. 12 year stand life
4. Labor @ $3.00/hour
5. 2 plow tractor @ $5.00/hour

INPUTS PER ACRE

PRODUCING YEARS	Labor Hrs.	Labor Value ($)	Machinery ($)	Other Item	Other Value ($)	Total cost ($)
Cultural Operations						
Apply fertilizer 1/	.2	.60	1.10	matl.	22.00	23.70
Irrigation (10x) 2/	1.5	4.50	1.50	water	12.00	18.00
Harvest 3/						
Swath				custom	2.00	2.00
Bale				custom	13.10	13.10
Haul and stack	1.2	3.00	5.00			8.00
Other Charges						
Land taxes 4/					4.50	4.50
Interest on land ($400/acre @ 8%)					32.00	32.00
Fence maintenance	.6	1.80			2.20	4.00
Operating capital interest (10%)					2.70	2.70
General overhead 5/					5.40	5.40
Amortized establishment cost (see over)					7.16	7.16
Cash cost			3.00		63.90	66.90
Non-cash cost		9.90	4.60		39.16	53.66
Total cost		9.90	7.60		103.06	120.56
Cost per AUM at 10 AUM's yield						12.06
Cost per AUM at 12 AUM's yield						10.50
Cost per AUM at 8 AUM's yield						15.07

1/ 200 lbs. of 16-20-0-4 per acre.
2/ Flood irrigate
3/ Harvest 2½ tons per acre off ½ of field (1 cutting).
4/ Based on land assessed for farm use value.
5/ Ten percent of cash operating expenses.

These data were developed by Gary Schneider, Area Extension Agent in Jackson and Josephine counties.

Department of Agricultural Economics, January 1975.

ESTABLISHMENT YEAR	INPUTS PER ACRE					
	Labor		Machinery	Other		Total Cost
	Hrs.	Value ($)	($)	Item	Value ($)	($)
Cultural Operations 1/						
Disc (2x)	1.0	3.00	10.00			13.00
Float or Harrow (2x)	.5	1.50	5.00			6.50
Seed 2/				custom	2.50	
				seed	20.00	22.50
Apply fertilizer				custom	2.50	
				50#P_2O_5	16.00	18.50
Other Charges						
Interest on land ($85/A at 9%)					7.65	7.65
Taxes on land					.80	.80
Operating capital interest (9%)					1.80	1.80
General overhead					3.00	3.00
Total establishment cost		4.50	15.00		54.25	73.75
Amortized establishment cost (10 yrs. @ 9%)						11

1/ This assumes the stumps and brush have been cleared from the land.

2/ Eight pounds subclover, 2 pounds white clover, and 15 pounds grass seed mixture.

OREGON STATE UNIVERSITY EXTENSION SERVICE

HILL PASTURE
Coos County

Based on:

1. 30 acres
2. 4 AUM/acre (producing years)
3. 10 year stand life
4. Labor at $3.00/hr.
5. 60 DBHP crawler tractor at $8.00/hr.

	INPUTS PER ACRE					
	Labor			Other		Total
PRODUCING YEARS	Hrs.	Value ($)	Machinery ($)	Item	Value ($)	cost ($)
Apply fertilizer				custom	2.50	
				50#P_2O_5	16.00	18.50
Weed control (mow and spot spray)					2.00	2.00
Other Charges						
Interest on land ($85/A at 9%)					7.65	7.65
Taxes on land					.80	.80
Fence repair and maintenance					.50	.50
General overhead					3.00	3.00
Amortized establishment cost (10 yrs. @ 9%)					11.49	11.49
Cash costs					24.80	24.80
Non-cash costs					19.14	19.14
Total costs					43.94	43.94
Cost per AUM at 3 AUM's yield						14.65
Cost per AUM at 4 AUM's yield						10.99
Cost per AUM at 5 AUM's yield						8.79

These data were developed by County Agent Lynn Cannon and Farm Management Specialists in cooperation with Coos County farmers.

Department of Agricultural Economics, October 1974

ESTABLISHMENT YEAR	INPUTS PER ACRE					
	Labor			Other		Total
	Hrs.	Value ($)	Machinery ($)	Item	Value ($)	cost ($)
Cultural Operations						
Disc, 8' (3x)	1.0	3.00	5.50			8.50
Disc and harrow 8' (3x)	1.0	3.00	5.50			8.50
Fertilizer 1/	.2	.60	1.10	mtl.	23.20	24.90
Harrow and roll 8' (2x)	.5	1.50	2.70			4.20
Drill, 8' 2/	.3	.90	1.70	seed	9.00	11.60
Irrigation (10x) 3/	1.5	4.50	1.50	water	12.00	18.00
Other Charges						
Land taxes 4/					4.50	4.50
Interest on land (400/acre @ 8%)					32.00	32.00
Operating capital interest (10%)					2.50	2.50
General overhead 5/					5.10	5.10
Cash cost			7.20		56.30	63.50
Non-cash cost		13.50	10.80		32.00	56.30
Total cost		13.50	18.00		88.30	119.80
Hay produced (2 ton less harvest cost)						(71.00)
Net establishment cost						48.80
Amortized establishment cost (12 years @ 10%)						7.16

1/ Assumes 40 pounds N and 40 pounds P_2O_5 per acre.

2/ Tall fescue or perennial ryegrass plus ladino clover

3/ Flood irrigate

4/ Based on land assessed for farm use value

5/ Ten percent of cash operating expenses.

Oregon State University

MEADOW HAY
Enterprise Data Sheet

Baker Co. 2/71
Cooperative Extension Service

Based on:

1. 300 acres (flood irrigated)
2. Yield 2.5 tons per acre
3. Operator's labor at $3.00/hr.
4. Hired labor at $2.00/hr.
5. 60 H.P. tractor at $3.50/hr.
6. 14 S.P. Swather at $10.00/hr.

	INPUTS PER ACRE					
	Labor			Other		Total
	Hrs.	Value	Machinery	Qty.	Value	Cost
Cultural operations 1/						
Harrow (12')	.2	.60	.50			1.10
Irrigate (5x)	2.0	4.00	1.50	water	4.00	9.50
Fertilize				custom	10.00	10.00
Harvest costs						
Swathing	.25	.75	2.50			3.25
Baling	.5	1.50	3.75	twine	1.25	6.50
Bucking and stacking (3 men)	1.5	3.00	3.25			6.25
Fencing hay yards	.3	.75		mtl.	.25	1.00
Other charges						
Interest on land investment, $300/acre @ 6%					18.00	18.00
Taxes on land					5.00	5.00
Interest on operating capital @ 8%					.80	.80
General overhead 2/					1.70	1.70
Total cash costs		7.75	4.60		21.75	34.10
Total non-cash costs		2.85	6.90		19.25	29.00
Total costs (cash and non-cash)		10.60	11.50		41.00	63.10
Aftermath grazing (1 AUM/acre)						(4.50)
Net cost per acre						58.60
Cost/ton at 2 ton yield						27.80
Cost/ton at 2½ ton yield						23.45
Cost/ton at 3 ton yield						20.55

1/ Consult your county agent for recommendations on specific practices.
2/ Approximately 5% of cash costs.

These data were obtained and computed by county agent Gus Markgraf and farm management technologist Stanley D. Miles in cooperation with Baker County ranchers in February, 1971.

HORTICULTURE

(ASEXUAL PROPAGATION)

Instructor's Guide

1. This is the first two units in horticulture that are provided for instructor option. Asexual propagation and pruning are included as optional units.
2. Selection of these units are based on the assumption that seed propagation was covered in the Ag I curriculum.
3. Instruction of these units must be "hands on" if it is to be meaningful to students.
4. If a greenhouse facility is not available for this unit, "hands on" instruction can be provided by building propagation units with plastic covered greenhouse flats.
5. This unit was obtained from curriculum developed by the University of Illinois, Urbana, Illinois.
6. If the horticulture units are to be used as the plant science instruction for the year the timing of the unit must be changed (i.e. propagation of semi-hardwoods, fall; soft woods, spring; herbaceous plants, anytime; division, late fall; separation, winter; whip and tongue graft, winter; and T-budding, early spring).

Objectives

Upon completion of this unit, the student will be able to:

1. Describe the four types of stem cuttings that can be used to produce plants by asexual propagation.
2. Propagate plants by hardwood cuttings. (i.e. grape, fig, forsythia.)
3. Propagate plants by semi-hardwood cuttings. (i.e. rhododendron, azalea.)
4. Propagate plants by softwood cuttings. (i.e. lilac, forsythia.)
5. Propagate plants by herbaceous cuttings. (i.e. geraniums, coleus.
6. Propagate plants by leaf cuttings. (i.e. African violets, rex begonia.)
7. Propagate plants by layerage. (i.e. rubber plant, blackberry.
8. Propagate plants by division. (i.e. peony, day lily.)
9. Propagate plants by separation. (i.e. tulip, daffodil, gladiola.)
10. Prepare a rooting medium.
11. Prepare and place cuttings in rooting medium.
12. Make a whip and tongue graft.
13. Make a cleft graft.
14. Make a T - bud.

Teaching Aids

1. Greenhouse propagation bench and/or greenhouse flats with plastic covers.
2. Rooting hormones.
3. Knife and pruning shears.
4. Plant materials.
5. Soil media.
6. Transparencies or live plant materials for demonstration of various types of cuttings.

Student Activities

1. Read objectives and material in unit.
2. Mix soil media.
3. Make a variety of cuttings.
4. Place cuttings in rotting media.
5. Control humidity and temperature of rooting bed.
6. Check cuttings periodically for signs of rooting.
7. When rooted, transplant cuttings into appropriate size containers.
8. Practice at least 2 types of layerage propagation.
9. Propagate a plant by division.
10. Propagate a plant by separation.
11. Graft fruit trees by whip and tongue method.
12. Prepare and place T - buds in fruit tree limb.

References

1. Hartmann and Kester, Principles and Practices of Plant Propagation.
2. Sunset Books - Available at Fred Meyer and Payless.
3. Ortho Books - Available at Fred Meyer.
4. Working in Horticulture, Richardson & Moore, McGraw-Hill Book Co., 1980.
5. Introductory Horticulture, Reily & Shry, Delmar Pub., 1979.
6. Horticulture, Halfacre & Barden, McGraw-Hill Book Co., 1979.
7. Plant Propagation Principles and Practices, Hartmann & Kester, Prentice Hall, 1975.

PRODUCING PLANTS BY ASEXUAL PROPAGATION

1. How Can I Propagate New Plants?
2. What Material Should I Use as a Rooting Media?
3. How Should I Place the Cuttings in the Media?
4. How Do I Graft Plants?

Asexual propagation is the production of a new plant from a growing part of a parent plant. This method of propagation is faster than growing from seed and assures you plants with the same characteristics as the parent. Many plants do not come true from seeds.

1. HOW CAN I PROPAGATE NEW PLANTS?

Such parts as roots, stolons, rhizomes, tubers, stems, or leaves may be cut into pieces and used with or without buds to produce new plants. These pieces take root and develop into a complete plant, similar in all characteristics to the parent plant from which it was taken. The type of cutting used to increase a particular plant will be determined by some of the following factors: ease of root or shoot formation, availability of propagation material, facilities available for propagation, season of the year, and the availability of skilled labor.

Stem cuttings may be divided into 4 groups, hardwood, semihardwood, softwood, and herbaceous.

Hardwood cuttings (of deciduous species) should be taken from wood of the previous season's growth in the late fall when the plants are dormant. Make the cuttings about 4 to 12 inches long and be sure to include at least 2 leaf nodes. First cut the tip of the branch back to where the wood is about the size of a lead pencil and make the basal cut slanting at a 45° angle a quarter inch below a node. Tie the cuttings in convenient sized bundles in late fall or early winter and store them upside down in moist sawdust or a mixture of sand and peat to prevent dehydration. Keep the medium moist through the winter. The early spring warmth will heat the root ends first causing roots to form. Be sure to label the bundels with the name of the plant and the cutting date.

In April, remove the cuttings from storage and plant them in the field or in coldframes, inserted right end up, and keep them moist until well rooted. Hardwood cuttings can be made from many shrubs and trees, such as forsythia (Forsythia sp.), weigela (Weigela sp.), or dogwood (Cornus sp.). However, some trees and shrubs do not root satisfactorily from hardwood cuttings. They are: birch (Betula sp.), beech (Fagus sp.), linden (Tilia sp.), maple (Acer sp.), oak (Quercus sp.), and some nut and fruit trees. These are normally propagated from seed, grafting, or budding.

Semihardwood cuttings are usually made from broad-leaved evergreen species, such as: Camellia (Camellia japonica), evergreen Azaleas (Rhododendron sp.), and Glossy Abelia (Abelia Grandaflora). Make cuttings 3 to 6 inches long, with the upper leaves left on and the lower ones removed. Be sure the base cut is made just below a node. Root them under conditions of high humidity, and with bottom heat. Growth regulators, such as "Rootone," are often helpful.

Softwood cuttings are made from soft, succulent wood of the current season's growth of deciduous and evergreen species, such as French lilac (Syringa sp.), forsythia (Forsythia sp.), and magnolia (Magnolia sp.). They root easier and quicker than hardwood cuttings but require more attention. This type is always made with leaves attached and must be rooted under conditions of high humidity and a suitable temperature. Growth promoting substances usually help. Softwood cuttings can be taken any time in the early summer during the active growing season.

Herbaceous cuttings are used to propagate the great majority of our greenhouse crops, such as geraniums (Geranium zonale), chrysanthemum (Chrysanthemum morifolium), and coleus (Coleus blumei). A simple demonstration on propagation of plants by stem cuttings is found in the Appendix. Be sure the plants from which the cuttings are taken are in good health. Never use weak or diseased material. Also, be sure the growth from which cuttings are taken is not too old. This growth is slow to root and slow to grow, making poor plants. Properly selected growth will snap off cleanly when bent sharply (Fig. 1).

Fig. 1 Softwood cuttings should be selected on gowth that snaps off cleanly when bent sharply (A). Older growth, as shown in B, bends but doesn't break and is not as satisfactory.

Make the cut just below a node. Vines in general root 1/8 to 1/4 of an inch below the node, while some cuttings (like coleus) root as readily from the internodes.

Terminal cuttings 2 to 5 inches long are usually the best for the herbaceous type. However, stem cuttings of two or more nodes may often be used, as with English Ivy (Hedera helix). In making the

cuttings, remove the lower leaves, leaving no debris on the part of the stem to be placed in the rooting media. Some leaves should be left on the cutting to supply food for the development of roots. While it is necessary to reduce the size of the leaves for the benefit of the cuttings, this is often done to allow more cuttings to be placed in a given amount of bench space and reduce the water loss from the cutting.

Stem cuttings

There are three types of cuttings -- the straight or regular cutting, the mallet cutting, and the heel cutting. A straight cutting is the type most commonly used. Heel and mallet cuttings are used where the older tissue will increase the percent of rooting and to get more cuttings from limited materials.

A mallet cutting consists of a section of older stem tissue at the base of the cutting. The older tissue is 1/2 to 1 inch long and cutoff squarely above and below the node. On plants with opposite branches, the older stem can be split down the middle to provide one-half a mallet for each cutting.

A heel cutting consists of a section of the older stem attached to the cutting. The heel cutting is produced by stripping a side branch from the main stem and getting a small amount of wood from the node area of the main stem. These three types of cuttings are shown in Fig. 2.

Leaf cuttings

Leaves of certain plants may be used to produce new plants. Some of these are used with petiole, while others are cut in various ways.

African violet (Saintpaulia ionantha) - The entire leaf with petiole is used.

Rex begonia (Begonia Rex) - The entire leaf is laid on the sand, after cutting the main veins, and inserted in the sand.

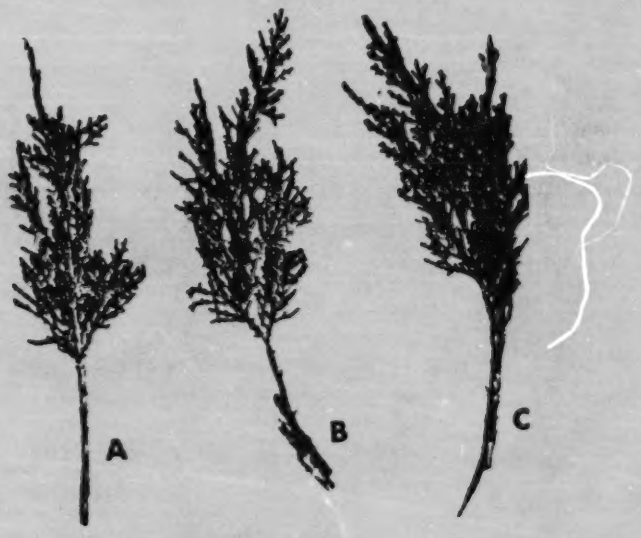


Fig. 2 Three types of cuttings: A, straight or regular; B, mallet; and C, heel.

Bryophyllum (Kalanchoe pinnatum) - The entire leaf is laid on moist sand. Plants start at notches on the leaf.

Temperature and moisture relations are the same for leaf cuttings as for herbaceous or softwood cuttings. Demonstrations on leaf cuttings are found in the Appendix and may be used to illustrate this method of propagation.

Bulb cuttings

A bulb is a specialized organ consisting of shortened stem tissue surrounded by fleshy scales. Tunicate bulbs (onion) have scales in concentric layers around the stem tissue. Scaly bulbs (lily) have loose scales around the stem tissue.

Scaly bulbs are propagated by removing some scales and planting them 1/2 their length in a suitable medium. Bulblets will form at the base of each scale (Fig. 3). Tunicate bulbs are propagated by "scooping" or "scoring". Large mature bulbs are used and all the stem tissue is removed in the process of scooping. Two or three "V" cuts are made completely through the stem tissue in the scoring process. The bulbs are callused for a few days and then grown in flats with the bottom side up. Bulblets will form at the cut bases of the scales. A demonstration on bulb multiplication may be found in the Appendix that will illustrate this method of propagation.

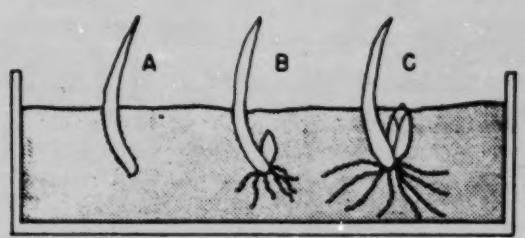


Fig. 3 Scaly bulbs, like the lily, are propagated by planting scales ½ their length in a suitable medium. Bulblets will form at the base of each scale.

Root cuttings

Root cuttings may be made from roots of any plant which will produce adventitious shoots. Cut the roots into 2 to 3 inch sections and place in propagating medium or bench with bottom heat. Some examples of plants that can be propagated from root cuttings are sweet potato (Ipomoea batatus), phlox (Phlox sp.), and oriental poppies (Papaver orientalis).

Tuber cuttings

Examples of tuber cuttings are Irish potato (Solanum tuberosum), caladium (Caladium bicolor), and dahlia (Dahlia pinnata). This is properly called a stem cutting, since the tuber is a thickened, specialized stem. Be sure each has an eye (Fig. 4).

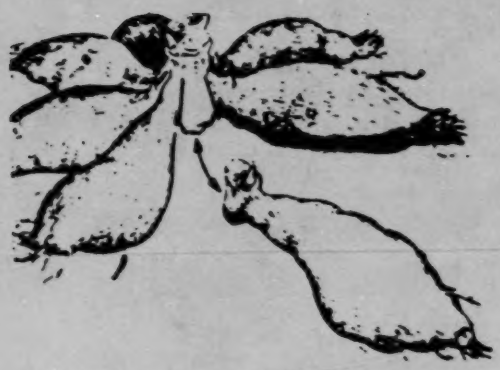


Fig. 4 Dahlia can be divided to produce new plants. Be sure each cutting has an eye.

Rhizome cuttings

Canna (Canna sp.), iris (Iris sp.), and rhubarb (Rheum rhaponticum) develop from underground stems in the same manner as tuber cuttings. Two bad weeds, quackgrass (Agropyron repens) and perennial field bindweed (Convolvulus arvensis) are also propagated accidently in this manner.

Layerage

In the practice of layering, new plants are started from branches from the parent plant.

Tip layering - The tip of a shoot is bent downward until it touches or is pinned to the soil and where it will develop roots.

Simple layering - A branch is placed in a trench 2 or 3 inches deep and covered with soil, allowing only 6 to 12 inches of tip to be exposed. Wounding the stem often hastens root formation. Currant (Ribes sp.), and forsythia (Forsythia sp.) are examples of plants that can be propagated by this method.

Air layering - A stem of a plant is wounded, usually be notching, and then covered with moist sphagnum moss, and covered with plastic. Roots form above the notch. When well rooted, cutt off the tip below the moss and pot. This is a common method for the propagation of such plants as crotons (Croton variegatum pictum) and rubber plants (Ficus elastica). Use demonstration on air layering found in the Appendix to illustrate this method of propagation.

Runners - Propagation by runners is a natural form of layering involving a specialized plant part. Some grasses, such as zoysia (Zoysia japonica), produce runners freely. Roots form at the nodes in these plants. Many plants spread naturally by runners, or they may be propagated readily by separating rooted runners from the parent plants and setting them in a new location. This is a common procedure in the production of new strawberry (Fragaria sp.) plants.

Division

In this method use clumps of plants that do not naturally break apart but must be cut or torn from the parent. This practice constitutes propagation by division. Some plants which may be propagated by this method are: agava (Agava americana), peony (Paeonia sp.), iris (Iris sp.), and day lily (Hemerocallis sp.) (Fig. 5).

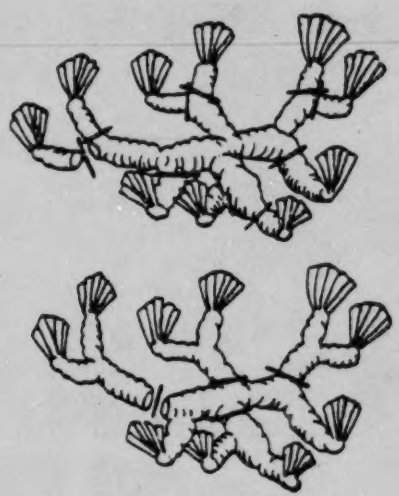


Fig. 5 New plants can be produced in iris by division. The lines indicate possible areas where they can be divided.

Separation

The propagation of naturally detachable structures, such as bulbs (tulip and daffodil), and corms (gladiolus) are commonly propagated by this method.

2. WHAT MATERIAL SHOULD I USE AS A ROOTING MEDIA?

Rooting media for herbaceous cuttings vary greatly. The most commonly used material is clean sand. It should be fine enough to hole moisture around the cutting and coarse enough to drain freely. Other materials that are satisfactory to use are vermiculite, perlite, soil, and in some cases water. A mixture of peat and perlite is also very popular, but various combinations of materials are often used.

A sterile media, free of rapidly decaying organic matter, is necessary. Use flats for propagation in the greenhouse and clean them thoroughly after each use. All media must be sterilized after every use to prevent disease build up.

3. HOW SHOULD I PLACE THE CUTTINGS IN THE MEDIA?

When inserting cuttings in the rooting media (as sand), make a straight line with some tool. Then insert the cuttings in the slit left by the tool.

Be sure the cuttings are placed in the media right side up, that is, with the end that previously pointed toward the terminal growth of the plant up and the end that was nearest to the root down. This is easily done with terminal stem cuttings of upright growing plants, but must be watched carefully in the case of hanging vines and sectional leaf cuttings of sansevierias. Plant-manufactured food travels only in a downward direction and is necessary to produce roots.

The cuttings should be spaced in the row in such a manner as to avoid excessive leaf overlap. Most greenhouse cuttings are inserted 1/2 to 1 inch apart in the row and rows 1 to 1 1/2 inches apart. Following insertion, firm the rooting medium around the stems. After a flat has been filled with cuttings, water it generously. In very bright conditions, it may be desirable to cover or shade newly set cuttings until they are rooted.

Unless the propagating equipment includes an intermittent mist system, the cuttings should be shaded for the first few days. This shade may gradually be reduced as root formation develops. With a system of intermittent misting, this may be reduced or eliminated entirely.

4. HOW DO I GRAFT PLANTS?

Grafting is the process of making a part of one plant unite and grow on a part of another plant. Any method that permits cambial contact between plant parts is a means of grafting. Some of the different terms that describe these grafts are called budding, whip and tongue, cleft, side, inarch, bark, and bridge grafting. The success or failure of each graft is based primarily on (1) the compatibility of each plant part, (2) the closeness of fit, and (3) the cambial contact. The objects of grafting are:

1. To alter plant character by modifying the wood, foliage, or fruit produced.
2. To develop branches, flowers, or fruit where they are lacking.
3. To repair damaged parts of trees.
4. To perpetuate clones that can not be reproduced in other ways.
5. To enhance the vigor of defective or exhasted trees and shrubs.
6. To facilitate seed production by grafting branches of the opposite sex on plants bearing unisexual flowers.

Some common terms used in grafting are as follows:

1. Scion is a piece of detached twig or shoot used in propagating the plant. It is the plant part inserted into the stock and for most kinds of grafting is the top part of the graft. The scion usually contains at least two or three buds. To be successful the cambium layer of stock and scion must be in close contact.
2. Stock is the portion of the graft to which the scion is attached. It may be a piece of root, a seedling, or a tree with part of the top removed in preparation for grafting.

3. Cambium is a very thin layer of living cells lying between the outer sapwood and the inner bark. Because cambium cells divide and make new cells, the cambiums of two different but related plants will grow together if they are fixed and held firmly in contact.

In general, grafting is limited to dicotyledonous plants, which have a cambium layer in a definite region under the bark. Grafting is usually easy between varieties of the same species and often between closely related species, although there are some cases in which distantly related species have been grafted successfully. There seems to be no rule to govern these distantly related grafts.

Some examples of the various kinds of grafts used on fruit trees will illustrate some of the principles of grafting.

Budding is the most common method of propagating new trees (Fig. 6). It is easier than whip and tongue grafting. Budding can also be used to change varieties on young trees that are from one to three years old. Budding can be done any time buds are fully developed and the bark slips, but most budding is done in July and August.

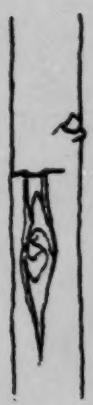


Fig. 6 Budding.

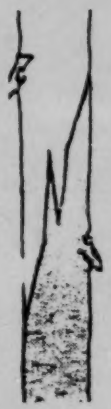


Fig. 7 Whip and tongue graft.

Fig. 8 Cleft graft.

Fig. 9 Side graft.

Whip and tongue grafting can be used to propagate nursery stock, to graft scion wood to a piece of root, and to top-work small trees. It is done from January to March, using dominant wood (Fig. 7).

Cleft grafting is commonly used for top-working trees, changing them from one variety to another. It works best on branches 1 to 2 inches in diameter, although it may be used on larger branches. This graft can be made anytime you can get dormant scion wood, but the best time is from January to March or April (Fig. 8).

Side grafting is also used for top-working trees (Fig. 9). It is faster than the cleft graft and is particularly suitable for branches from 1/2 to 1 inch in diameter. It can be made the same time of the year as the cleft graft.

Fig. 10 Inarch graft.

Fig. 11 Bridge graft.

Fig. 12 Bark graft.

Inarch grafting is used to repair bark injury (Fig 10). Young trees are set around the trunk of the injured tree and their tops are grafted into the trunk. This graft can be made only when the bark slips.

Bridge grafting is used to repair injuries in which large areas of bark have been destroyed (Fig. 11). Bridge grafting can be done only when the bark slips. Although it can be done as late as June, usually the sooner it is done after the bark slips in the spring, the better. The scion wood must be dormant.

Bark grafting can be used in place of the cleft graft to top-work a tree (Fig. 12). It is faster to make, but not always as suitable. Bark grafts can be made only when the bark slips. The sooner after the bark slips the better.

These are only a few of the various types of graft that you can make. However, the following ideas may help you make successful grafts.

1. Choose healthy, disease-free material for the scion. Be sure that the plant parts being grafted are compatible. Material should be well hardened. Material used for budding should have plump, well developed buds.
2. Use a sharp knife when shaping the graft and make straight, even cuts. A smooth, level surface is essential for maximum contact between stock and scion.
3. Make sure the cambiums of the stock and scion touch. For cleft and whip and tongue grafts, this means careful matching of the cambium of the stock with the cambium of the scion. For bridge, inarch, and bark grafts, it means making sure that all the cut surface of the scion is firmly in contact with freshly uncovered wood.
4. After fitting stock and scion together, keep them in contact. Wrap the graft, or nail it if there is not enough natural pressure to hold the stock and scion together. Whip grafts and buds should be wrapped, while bridge grafts and inarch grafts should be nailed. The bark graft can be wrapped or nailed, depending upon your preference.

5. Wax cut surfaces to keep out air and prevent entry of rot organisms. Buds do not need to be waxed since they are wrapped tightly and very little cut surface is exposed.

The following Appendix includes some simple demonstrations to help students develop skills and a better understanding of the propagation of plants. Each demonstration should fit into a pattern of logical steps that could be used throughout most of the ornamental horticulture industry. Students should be able to carry out these demonstrations as group projects or individually. Be sure to have students note and compare differences as they occur in the different demonstrations.

APPENDIX

PROPAGATION OF PLANTS BY STEM CUTTINGS

Purpose:

To demonstrate a method of propagating geraniums or chrysanthemums by stem cuttings.

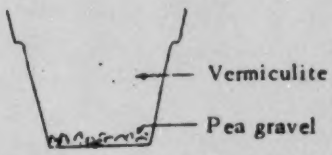
Materials:

1. Vermiculite.
2. Geranium or chrysanthemum stock.
3. A 6-inch flower pot.
4. A small porous clay pot (2 to 3 inches).
5. A cork.
6. A plastic bag.
7. Four stakes or a framework of heavy wire (coat hanger) to support the plastic bag.
8. A rooting powder (Hormodin #2).

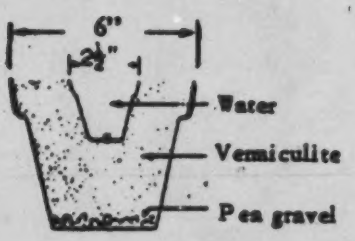
Directions:

Preparing the pots for cuttings

1. Select a clean 6-inch flower pot that has bottom drainage.
2. Cover the drainage hole with pea gravel or a plastic drain-hole cover.
3. Fill the pot about half full of vermiculite. (Clean sand, or a mixture of shredded peatmoss and sand can be used, but usually they are not satisfactory as vermiculite because they often contain high amounts of sodium (Na) or sodium salts).



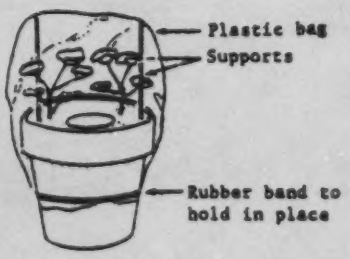
4. Then place a small 2 - to 3-inch unglazed porous clay pot in the center. The rims of the two pots should be about the same height.
5. Plug the drainage hole of the small pot with a cork.
6. Fill the space around the small pot with vermiculite, almost up to the rim of the larger pot.
7. Slowly moisten the vermiculite with water. Set a pan under the large pot to catch any excess water that may drain through.
8. Fill the small pot with water. This gives the cuttings a constant supply of moisture, because water seeps through the sides of the small clay pot into the vermiculite.



Making the cuttings:

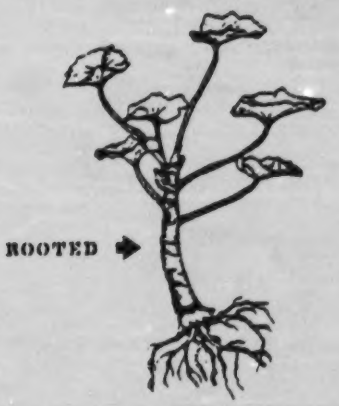
1. Select the possible cuttings from a well grown, healthy plant.
2. Make stem cuttings about four inches long. The cut should be made about 1/4 inch below a node.

3. Remove all leaves from the lower 1 1/4 inches of the stem.
4. Dust the cut end and lower one inch of half of the stem cuttings with a rooting powder. (Available from most florists or garden supply stores). Leave the other half untreated.
5. Immediately insert the bases of each of the cuttings about 1 - 1 1/2 inches into the moist vermiculite.
6. When the cuttings are all in place, insert the bent wire or stakes which will support the polyethylene bag. Place the bag over the cuttings and down the side of the pot. This will help conserve moisture and keep humid air around the foliage.



7. Place a rubber band around the pot to hold the plastic bag in place.

8. Cut five pencil sized holes in the plastic "greenhouse" for ventilation.
9. Then place the cuttings under a fluorescent light (6 to 8 inches above the top of the cuttings) or in an area which receives bright light. They should NOT receive the direct rays of the sun as temperature may get too high. If possible, regulate the temperature at about 65° F. If placed on a window sill in the winter, the pot temperature may remain too cool.
10. Check the water in the small pot weekly, and add more as necessary. If the vermiculite seems somewhat dry, sprinkle it lightly too.
11. Carefully remove the cuttings and pot them once the roots are at least one-half inch long. Well-developed roots should be formed in about three weeks.



Observations:

Compare the treated cutting with the untreated ones for: time necessary for rooting to take place and the number of roots.

Explanation:

Geraniums are one of the most popular house and outdoor bedding plants. They grow and produce flowers with a minimum of care. Cuttings can be started quite easily by propagation from healthy stock. Flowering usually begins two to four months after the cuttings are started if the plants are kept growing at a moderate rate.

Cuttings should be started during August for winter flowering. If plants are wanted for spring flowers indoors or for bedding outside, start cuttings in February. The best stock for cutting comes from plants that have been rather dry for several weeks, with the growth firm and ripened rather than succulent.

Geraniums grown indoors during the winter prefer full sunlight, relatively cool temperatures (55° to 60° F. night, 70° to 75° F. day), soil kept a little on the dry side most of the time, and good ventilation. Over-watering indoor plants during the winter is a common mistake. Too much water, either in the pots or on the foliage,

may cause spotting of the leaves or may produce luxurious vegetative growth rather than flowers.

GERANIUM

As the plants develop and become potbound, it will be necessary to shift them to successively larger pots. When repotting, press the soil firmly around the roots. This precaution helps to insure short, stocky growth and the development of flower buds.

Some plants that can be propagated by stem cuttings:

A. Flowering plants

Ageratum (Houstonianum)
Fibrous rooted begonia (Begonia semperflorens)
Chrysanthemum (Chrysanthemum morifolium)
Fuchsia (Fuchsia hybrida)
Geranium (Pelargonium domesticum)
Impatiens (Impatiens balsamina)
Lantana (Lantana camara)
Poinsetta (Euphorbia pulcherrima)

B. Various foliage plants

Aluminum plant (Pilea cadierei)
Arrowhead plant (Syngonium podophyllum)
Chinese evergreen (Aglaonema simplex)
Coleus (Coleus hybridus)
Devil's Ivy or Pothos (Scindapsus aureus)
English Ivy (Hedera helix)
Grape Ivy (Cissus rhombifolia)
Iresine (Iresine herbsti or lindeni)
Jade plant (Crassula argentea)
Japanese boxwood (Buxus microphylla)
Peperomia (Peperomia obtusifolia or sandersii or caperata)

Philodendron (sp. -- many types)
Velvet plant (Gynura aurantiaca)
Wax plant (Hoya carnosa)
Wandering Jew (Tradescantia fluminensis and Zebrina pendula)

Propagation of chrysanthemums by cuttings

1. Allow established chrysanthemum plants to grow until the stems are 8 to 10 inches tall.
2. Cut or break off the top 3 to 4 inches from the strongest, healthy stems.
3. Dip the bottom 1/2 inch of the cutting in a hormone powder to stimulate rooting.

4. Insert the base of the cutting to a depth of 1 1/2 to 2 inches in the rooting medium. You may plant in the vermiculite pot propagator or shallow boxes filled to a depth of 4 to 6 inches with a mixture of 1 part of peat to 1 part sterile sand, perlite, or vermiculite. Mix the two materials thoroughly.
5. Water immediately and thoroughly. Water daily or as needed. The plants should not be allowed to wilt. The container of cuttings may be enclosed with plastic film to reduce water loss and enhance rooting as explained previously.
6. Set in a warm (65^{o}) but shaded place.
7. Pot cuttings when the roots are about 1/2 inch long.

PROPAGATION OF AFRICAN VIOLET PLANTS

Purpose:

To demonstrate propagation of African violet plants using leaf cuttings.

Materials:

1. African violet plant.
2. Clean sharp sand or a mixture of equal parts by volume of peat-moss and horticulture grade perlite.
3. One container 2 to 4 inches deep, such as a wooden or metal flat or a rubber or plastic dish.
4. Cheesecloth or sphagnum moss.
5. A drinking glass.
6. Aluminum foil.

Directions:

1. Prepare a flat as follows:
   a. Provide holes for adequate drainage if not already present.
   b. Cover the holes in the container with cheesecloth or sphagnum moss.
   c. Fill the container with the propagating medium of either the sand or peat-perlite mixture.
   d. Water the medium in the container until thoroughly wet and let drain.
2. Select 4 to 6 mature healthy leaves from an African violet plant. Remove the entire leaf with its petiole by snapping it off at the stem of the plant.
3. Cut the petioles of the leaves so that two leaves have one-inch petioles, one leaf has a two-inch petiole, and one leaf has a three - to four-inch petiole. Cut one of the leaves with the one-inch petiole in half as illustrated.

4. Fill the drinking glass with water. Cover the glass with aluminum foil and punch a hole in the center of it with a pencil. Place the petiole of the leaf with the two-inch petiole through the hole until the base of the leaf blade rests on the foil.
5. Place the remaining cuttings in the flat as follows:
   a. Place the leaves with petioles in the propagating medium up to the lower edge of the leaf blade.

b. Insert the upper half of the leaf cutting so that 2/3 of the blade is above the medium.

6. Water the medium after the cuttings are in place to give good contact between the cuttings and medium.
7. Add water as needed to keep the medium moist and the glass full.

Observations:

Record the time for the new plants to emerge and the number of plants for each of the leaves. Is there any difference between the type of cutting and the number of plants produced or the amount of time needed to produce new plants? Which medium was easier to use? Which type of cutting would work best in large scale production?

When removing a cutting from the medium, loosen the medium around the cutting by placing a stick or finger under the cutting and pulling upward. When the medium is loose, then carefully remove the cutting to avoid breaking off any roots or shoots. To replace the cutting, place it back where it came from and fill around the cutting with medium. Water the area around the cutting to firm the medium again.

Explanations:

Propagation by leaf cuttings is the standard method of propagation for plants possessing fleshy leaves, leaves with enlarged thickened petioles, or leaves with characteristically large veins.

Leaves of some horticulture plants produce roots only, and under no circumstances can they be induced to produce stem tissue. It is; however, possible in the laboratory, by means of tissue culture techniques and with the application of hormones to induce many of these leaves to differentiate stems.

New plants develop from new tissue that is produced at the base of the leaf blade or the cut end of the petiole. The new tissue is formed from secondary meristems, which are cells that have changed from a mature to immature condition. The roots develop first and shoot development follows in a few weeks. Each leaf will generally produce a number of plants (2-10).

Optimum conditions for propagation are 70° F., high humidity, and medium to low light intensity. Four to nine months are needed to produce a flowering plant from a leaf cutting.

STARTING PLANTS FROM LEAF-BUD CUTTINGS (GERANIUMS)

Purpose:

To demonstrate a method of propagating plants from leaf-bud cuttings.

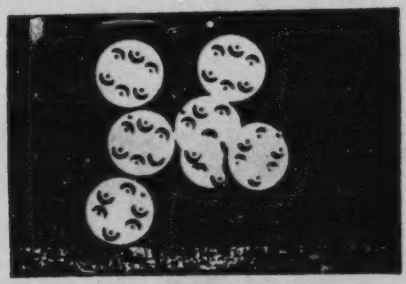
Materials:

1. Vermiculite (No. 2).
2. Geranium stock plants.
3. A 6-inch flower pot.
4. A small unglazed pot (2 to 3 inches).
5. A cork.
6. A plastic bag.
7. Four stakes or a framework of heavy wire (coat hanger).
8. A rooting powder.

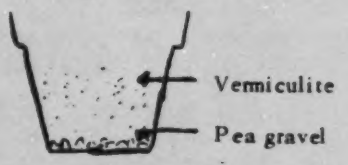
Directions:

Preparation of the pots for cuttings

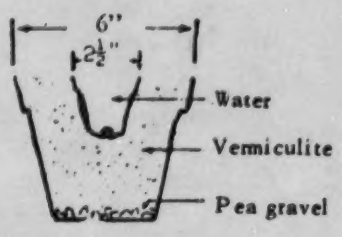
1. Select a clean large flower pot (6 inches in diameter) that has bottom drainage.
2. Cover the drainage hole with pea gravel or a plastic drain hole cover.



3. Fill the pot about half full of vermiculite (Clean sand, or a mixture of shredded peatmoss and sand can be used).
4. Then place a small 2 - to 3-inch unglazed clay pot in the center. The rims of the two pots should be about level.



5. Plug the drainage hole of the small pot with a cork.
6. Fill the space around the small pot with vermiculite, almost up to the rim of the two pots.



7. Slowly wet the vermiculite with water. Set a pan under the large pot to catch any excess water that may drain through.
8. Fill the small pot with water. This will give the cuttings a constant supply of moisture, because water seeps through the sides of the small clay pot into the vermiculite.

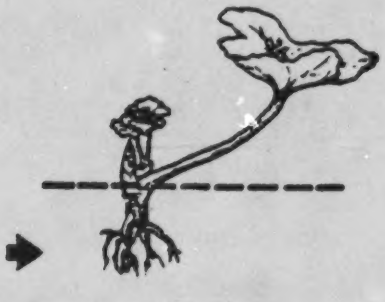
Making leaf-bud cuttings:

1. Select leaves which have a mature axillary bud capable of producing shoots in a relatively short period of time. Cuttings should only be taken from disease-free plants.
2. Remove a single leaf with only enough of the stem tissue to retain the bud, which is found in every leaf axil. Be careful not to damage the bud and make the cut as smooth as possible.

3. Treat the cut surface of half of the leaf-bud cuttings with a hormone rooting powder. (There are many kinds of rooting powders available from most florists or garden supply stores. Rooting powder greatly reduces the time for rooting and is widely used. Follow the manufacturer's directions on the container). Leave the other half untreated. Put the untreated cuttings in the propagator along with the treated cuttings to see just how much better the treated ones do.
4. Insert the bottom end of each stem into the wet vermiculite up to the base of the bud as shown. Do not cover the bud. Label the treated and untreated cuttings.

5. When the cuttings are all in place, put a polyethelene bag (plastic) over the cuttings and the large pot. This will help conserve moisture and keep humid air around the foliage.

6. Place a rubber band around the plastic bag and pot to hold the bag in place.
7. Cut fine pencil size holes in the plastic greenhouse for ventilation.
8. Then place the pot with cuttings under a fluorescent light (6 to 8 inches above the top of the plants) or in an area which receives bright light. They should not recieve the direct rays of the sun. If possible, regulate the temperature at about 65^{o} F.
9. Check the water in the small pot weekly, and add more as necessary. If the vermiculite seems somewhat dry, sprinkle it lightly too.
10. Carefully remove the cuttings and pot them when the roots are about one-half inch long. Well-developed roots should be formed in about three weeks. The leaf-bud will root as quickly as a stem cutting but will require more time to develop into a large plant. If geranium propagation is begun in the fall, good plants can be grown from leaf-bud cuttings for spring.



ROOTED

Observations:

Compare the time necessary for rooting to take place on the treated and untreated cuttings.

If propagation of stem cuttings is being carried on at the same time, compare rooting time of leaf-bud cuttings with stem cuttings.

BULB MULTIPLICATION (TUNICATED)

Purpose:

To learn how to propagate hyacinth (tunicated) bulbs.

Materials:

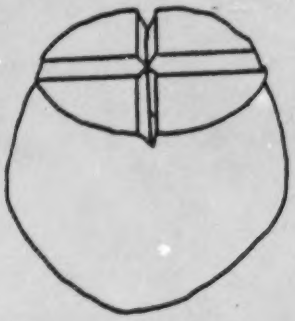
1. Four large size hyacinth bulbs (19 cm. and up).
2. A sharp knife.
3. A melon-ball scoop.
4. A container 2 1/2" to 4" deep, approx. 12" x 12".
5. Dry sand.
6. Liquid laundry bleach (Clorox).
7. Alcohol and alcohol burner.
8. A dry, warm (85°-90° F.) place to store the bulbs for 14 days.
9. A 4-6 oz. drinking glass.

Directions:

1. Peel off the outer tunic and all damaged scale leaves from the bulbs.
2. Mix about one quart of a sterilizing solution of one part bleach to 20 parts water.
3. Pour alcohol into the glass to a depth of 1 1/2" to 2 1/2".
4. Light the alcohol burner. Be careful not to light the alcohol in the glass.
5. Remove all the stem tissue (basal plate) from bulb using the melon-ball scoop. Cut only deep enough to remove the stem tissue and as little as possible of the fleshy leaves.

6. Dip the melon-ball scoop into the alcohol. Remove the scoop and pass it through the flame of the alcohol burner. Let the alcohol on the scoop burn off.
7. Repeat Step 5 on a second bulb.

8. On a third bulb, make two or three cuts across the base of the bulb with a knife. The cuts should be deep enough to go through the basal plate and expose the edges of the fleshy leaves. About 1/8" wedge shaped section through the basal plate should be removed at each cut.



9. Sterilize the knife in the same way as the scoop in Step 6.
10. Repeat Step 8 with the 4th bulb.
11. Dip the bulbs into the bleach solution for 2-3 minutes.
12. Remove the bulbs from the bleach solution and allow to drain on clean paper towels for 5-15 minutes.
13. Fill the container with dry sand to 1/2" of the top.
14. When the bulbs are ready from Step 12, place them into the dry sand. Place them cut face up, not touching the side of the container or other bulbs, and deep enough so the cut part is just above the surface of the sand.
15. Keep the container at the dry, warm (85^{o}-90^{o} F.) temperature until the cut surfaces of the bulb have callused (approx. 14 days).
16. The bulbs should be placed in the light and kept from drying out by periodic watering after they are callused.
17. After the bulbs begin to form new bulblets, pot the bulbs in a soil medium.

Observations:

Check to see if any fungus (mold) develops on the bulbs. If fungus is present, exactly where is it? Treat bulbs with a fungicide (captan) to kill the fungus. Note the time it takes before new bulblets are visible to the eye, and any size difference between the treatments. Where are the bulblets being formed on the bulbs?

Discussion:

Scooping and scoring are the methods used in this experiment. These methods are used commercially on hyacinth, scillas, and some grape hyacinth for producing new bulbs identical to the original bulbs.

The main problem with this method is to keep the tools sterilized to prevent the spread of fungus organisms. Secondary infection of fungus also occurs readily.

The scooping method should produce an average of 50-60 bulblets that require 4-5 years to produce a flowering size bulb. The scoring method should produce an average of 15-30 bulblets that will require 2-4 years to produce a flowering size bulb.

AIR LAYERING

Purpose:

To demonstrate how to root a plant by air layering.

Materials:

1. A Rubber plant (Ficus elastica), Fiddle leaf fig (Ficus lyrata), Dumbcane (Dieffenbachia species), Croton (Codiaeum species), or Cornplant (Dracaena species).
2. A sharp knife.
3. A rooting powder (Hormodin #2).
4. Sphagnum moss.
5. A container of water.
6. 10" x 10" sheet of clear polyethylene film.
7. Waterproof tape or plastic "Twistems".
8. Wooden match.

Directions:

1. Remove all leaves in an 8" section on the stem starting 6" to 18" from the outer tip of a branch.
2. Make a slanting cut in the stem about one inch long between two nodes in the center of the 8" section of cleared stem. The cut should not penetrate the stem more than one-half its diameter. You must use a sharp knife to make the cut.

3. Hold the cut open by using a small piece of wooden match or toothpick.

4. Apply a small amount of the root promoting powder to the upper cut surface of the stem.
5. If the stem seems to be very weak at the point where the cut was made, tape an 8" dowel to the stem opposite the cut if extra support is needed.
6. Saturate a large handful of sphagnum moss in a container of water.
7. Remove the moss from the water and squeeze as much water from it as you can by hand.
8. Place some damp moss in the cut. Place the remaining moss around the cut in the stem in a ball shape.

9. While holding the moss in place with one hand, use the other to cover the moss with a piece of polyethylene film.

10. Stretch the film tightly around the moss and tape or tie both ends tightly to the stem.

11. The branch will root in one to six months, depending on the type of plant used. When the roots can be seen through the plastic, the branch is ready to pot.

12. When a number of roots can be seen through the plastic, remove the plastic. Be careful not to injure the roots. Cut the branch just below the moss.

13. Place the cut-off branch into a container of water for 10 to 15 minutes.

14. Pot the branch and any moss still attached in an appropriate container. Place the plant in a cool (55^{o}-65^{o} F.), shaded area for one month until the roots have a chance to develop in the new container.

Observations:

Considerable difference in time is required to root the various kinds of plants. The cutting should be checked weekly to see when roots are visible under the plastic. When five or more large roots are visible, it is time to cut off the cutting and pot it.

Discussion:

Air layering has been used for hundreds of years as a way of reproducing plants. Two names applied to this method in other parts of the world are Chinese layerage and marcottage.

Keeping the peatmoss properly moistened has always been a problem

with this method. Since polyethylene film has been available, this problem has been easily overcome. The polyethylene allows an exchange of gas (CO_2 and O_2) between the peatmoss and air, but little loss of water from the peatmoss.

Air layering is used because it is very difficult to root some plants by any other means. The cutting of the stem prevents some of the food materials produced above the cut from going to the rest of the plant, and minerals to move above the cut. These conditions are favorable for the production of roots just above the cut.

Air layering is generally used only on a small number of plants because of the labor involved in making the cuttings.

HORTICULTURE

(PRUNING)

Instructor's Guide

1. This is the second of two units in horticulture that are provided as optional units.
2. Materials provided in this unit offer comprehensive treatment of pruning and involves the pruning of fruit trees, berries, and ornamentals. The instructor may select those applications most suitable to local situations.
3. Instructor should locate field sites for "hands on" instruction well in advance.
4. Instruction must be application oriented, with students having the opportunity to complete the total pruning of a tree or other plant.
5. The material in this unit was developed by the Vocational-Technical Division of the New Mexico State Department of Education.
6. Unit exams are included for instructor convenience.

Objectives

Upon completion of this unit, the student will be able to:

1. Use pruning tools properly.
2. Distinguish between "heading back" and "thinning out".
3. Understand the purposes of pruning.
4. Distinguish between "central leader" and "open center" training of fruit trees.
5. Identify flower buds, vegetable buds, fruiting spurs, and fruit scars on fruit tree limb.
6. Prune apple tree.
7. Prune peach tree.
8. Prune grapes and berries.
9. Prune roses.
10. Prune ornamental trees.
11. Prune deciduous and evergreen shrubs.
12. Identify special purpose pruning and training methods such as espaliers, pollarding, pleaching, and shearing.

Teaching Aids

1. Field sites for practical experience in pruning.
2. Pruning equipment.
3. Tree Heal compound.

Student Activities

1. Read objectives and material provided by instructor.
2. Prune trees and shrubs assigned by instructor.
3. Take unit exams over material in this unit.

References

1. Sunset Books, Sunset Pruning Book. Land Magazine and Book Company, Menlo Park, California, 1973.

Introduction to Pruning

I. Terms and Definitions:

A. Pruning - The removal of parts of the top or root systems of plants.

B. Fruit Spurs - Stubby fruit-bearing twigs up to three inches long.

C. Translocation - The movement (conduction) of water soluble organic materials and minerals from one part of the plant to another part.

D. Inhibit - To prohibit or slow down an action.

E. Hormones - A chemical compound that is produced in one part of a plant and moves to another part of the plant.

F. Twig - A very small branch of a tree.

G. Cane - A stem of various fruits such as the raspberry or blackberry.

H. Shoot - A small outgrowth on a bush.

II. Facts about Pruning.

A. Pruning is a task that generally has no specific season.

B. It is a continuous process.

C. It serves a purpose for the plant.

D. It enhances the ornamental value of plants.

E. Generally prune with the natural form of a plant, not against it (See TM 1).

III. Purposes of Pruning.

A. To remove diseased, dead, or damaged limbs.

B. To restrict or promote growth.

C. To encourage or improve blooming.

D. To develop certain forms of growth.

IV. Methods of Pruning.

A. Pruning the stem.

B. Pruning the root.

V. Facts About Stem Pruning.

A. Reduces the amount of growth.

B. Influences the vegetative-reproductive balance of the plant.

C. Removal of healthy stems and leaves reduces plant size, yield, and the total amount of growth.

D. Increases the supply of essential elements to the points of growth that remain.

E. Promotes the making of cells and the utilization of carbohydrates.

F. Stimulates the vegetative phase and retards the reproductive phase.

VI. Facts About Root Pruning.

A. Affects the total amount of growth made.

B. Influences the vegetative-reproductive balance of the plant.

C. Reduces the amount of available essential elements, and water that would go to the plant top - thus causing the plant to have a dwarf form.

D. Promotes root growth - the roots using the carbohydrates manufactured by the plant causing the plant to be dwarfed.

E. Favors reproduction and retards vegetative phases of the plant.

F. Also used to prepare a plant for transplanting.

VII. Types of Top Pruning.

A. Heading back.

B. Thinning out.

VIII. Facts About Heading-Back Pruning.

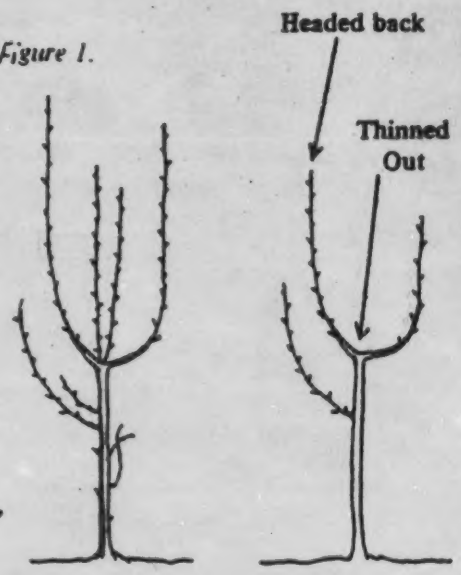
A. Terminal (top) portion of twigs, canes, or shoots are removed.

B. Stimulates the development of more points of growth.

1. Terminal buds on shoots secrete growth-inhibiting hormones which are translocated to the lateral buds.

2. Lateral buds just below the cut manufacture the growth-inhibitor hormones, which prevent the development of lateral buds farther down the stem.

Figure 1.



C. Induces compact, dense, or branched type of growth.

IX. Facts About Thinning-Out Pruning.

A. Entire twig, cane, or shoot is removed.

B. Does not prevent the development of lateral buds.

C. Induces open type of growth.

X. Some General Rules For Pruning.

A. Use only sharp and proper tools for the job.

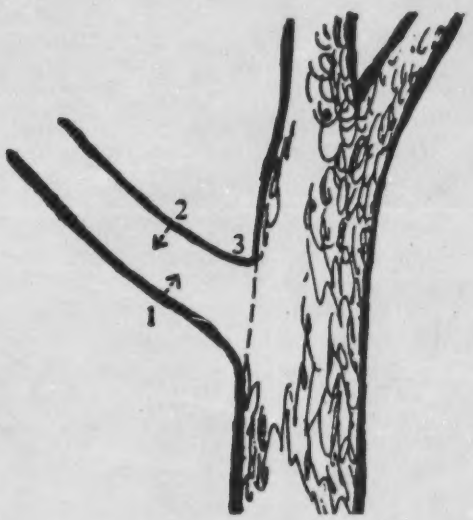
B. Prune back to an existing bud (about 1/4 inch above it) or to a side branch. NEVER LEAVE A STUB.

C. Cut larger limbs in three steps (See Figure 2):

1. Make an undercut on the limb 9 to 12 inches from the main trunk, cutting into about 1/3 of the limb's diameter.

2. Go out an inch or two from the undercut and begin cutting into the top of the limb. As the saw cuts into the wood, the weight of the limb will cause a separation to take place between these two cuts, and the limb will fall.

3. Cut off the stump that remains flush with the main trunk. Once the final cut is made, cover the cut area with tree paint.



D. Pruning in the summer months results in a greater dwarfing of trees than pruning in the late winter months.

E. Buy and plant trees and schrubs that have the characteristics, mature size, and shape you want. Do not count on pruning to keep tall plants short and spreading plants narrow.

XI. Pruning Tools And How To Use Them.

A. Thumb and forefinger - The most important.

1. Pinch off any lanky shoots that may spoil the symmetry of perennials or shrubs.

2. Rub out unwanted buds, long stems, and fruit spurs.

3. Snap off faded bloom or seed pods.

B. Edgers (See TM 2).

1. Enable user to stand up to cut the edges of lawns.

2. Will also cut the edges of thick, spreading ground covers, such as ivy and vines.

C. Grass Shears - Use only for shearing grass (not good for other plants).

D. Lopping Shears.

1. Used whenever the added leverage of long handles will make an easier cut.
2. Used for reaching farther into a tree.
3. Used on small branches or twigs.

E. Pruning Shears.

1. Essential part of any gardener's tool kit.
2. There are many different kinds for different tasks, such as:
   a. For small pruning jobs.
   b. For Bonsai pruning. Makes a concave depression, heals fast.
   c. Flower shears - have blades designed to cut and hold flower stems.
   d. Fruit shears - cut stems of fruits that don't break off (lemons and oranges).
   e. Extension shears - used for cutting flowers and doing other light pruning beyond arm's reach.

F. Hedge shears.

1. Designed to cut quickly through fresh, green, wet wood.
2. Generally have one blade serrated and notched - the notch holds bigger twigs for non-slip slicing.

G. Pruning Saws.

1. Hand-operated with various size handles.
2. Curved saws have teeth made to cut on the pull stroke - useful for overhead work.
3. Straight saws have teeth made to cut on the push stroke.

H. Pole pruners and pole saws.

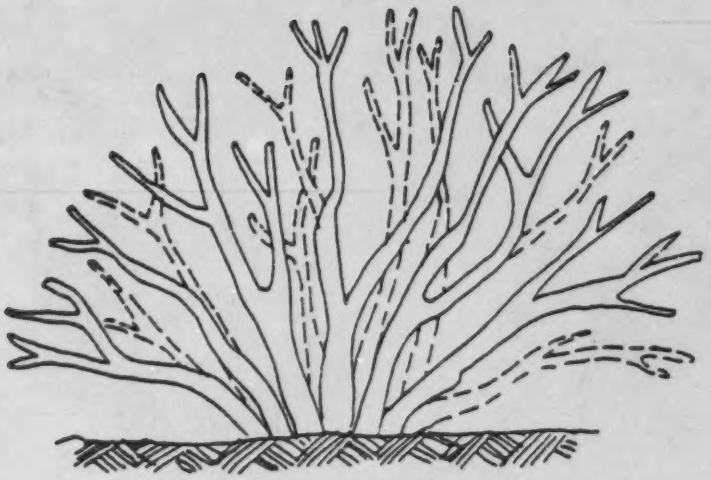
1. Used to cut or to saw branches high overhead.
2. A telescoping lightweight metal tube, or wooden poles that lock together, making an extension of up to 18 feet, at the end of which the pruning units are attached.

NOTE: FOR SAFETY'S SAKE, ***when using pole pruners or saws, be sure to avoid any contact with electrical power lines!***

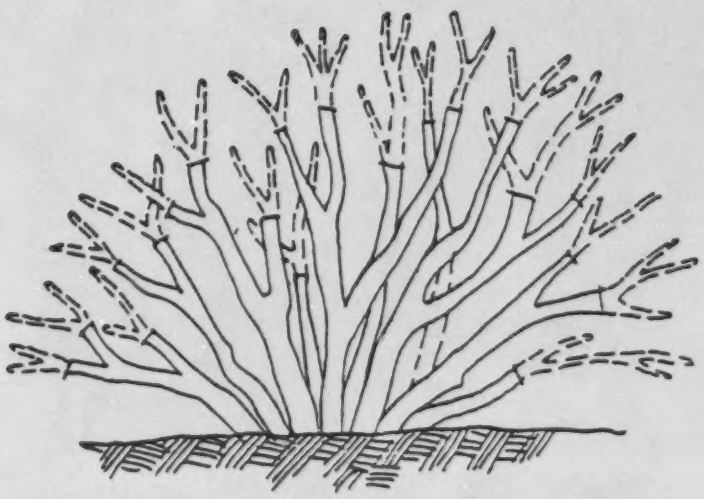
I. Chain saws - for pruning of large material.

NOTE: FOR SAFETY'S SAKE, ***never raise or lower a chain saw that is running and not cutting!***

Pruning Methods

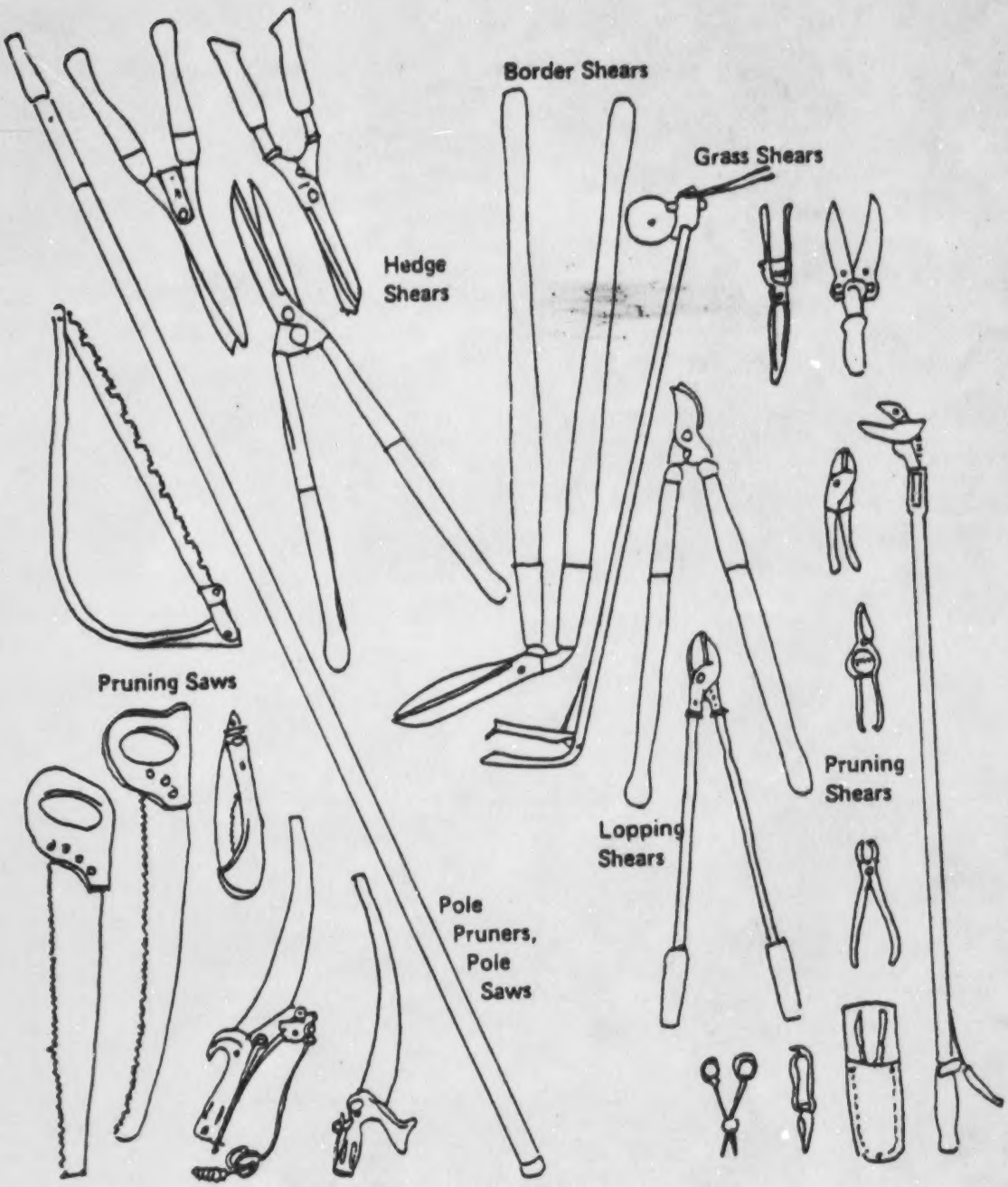


Correct Method



Incorrect Method

Pruning Tools



UNIT TEST:

1. Match:

_____a.	Inhibit	(1)	Stubby fruit-bearing twigs up to three inches long.
_____b.	Fruit spurs	(2)	The removal of parts of the top or root systems of plants.
_____c.	Hormones	(3)	To prohibit or slow down an action.
_____d.	Pruning	(4)	The movement of conduction of water soluble organic materials and minerals from one part of a plant to another.
_____e.	Translocation	(5)	Chemical compound that is produced in one part of a plant and moves to another part of the plant.
_____f.	Twig	(6)	A stem of various fruits, such as raspberry or blackberry.
_____g.	Cane	(7)	A very small branch of a tree.
_____h.	Shoot	(8)	A small outgrowth on a bush.

2. Choose from the following statements those that are true of pruning:

_____a. Pruning is a task that has no specific season.
_____b. Skills are not necessary to prune plants successfully.
_____c. It is a continuous process.
_____d. It does nothing for the value of plants.
_____e. Prune with the natural form of the plant, not against it.
_____f. It performs a purpose for the plant.

3. List three important aspects of plant maintenance.

4. Name two methods of pruning.

5. Identify as True or False the following statements about stem pruning.

_____a. Reduces the amount of growth.
_____b. Does not influence the vegetative-reproductive balance of the plant.
_____c. Removal of healthy stems and leaves reduces plant size and yield.
_____d. Decreases the supply of nitrogen and essential elements to growing plants that remain.
_____e. Promotes the making of cells and the utilization of carbohydrates.
_____f. Stimulates the vegetative phase and retards the reproductive phase.

6. Identify as True or False the following statements about root pruning.

_____a. Affects the total amount of growth made.
_____b. Influences the vegetative-reproductive balance of the plant.
_____c. Increases the amount of available essential elements and water that would go to the plant top.
_____d. Promotes root growth.
_____e. Favors reproduction and retards vegetative phases of the plant.
_____f. Is not used in transplanting plants.

7. Name two kinds of top pruning.

8. Choose from the following statements those that concern "heading back."

_____a. Terminal portion of twigs, canes, or shoots are removed.
_____b. Basal portion is removed.
_____c. Stimulates the development of more growing points.
_____d. Induces compact, dense, or much branched type of growth.

9. Choose from the following statements those that concern "thinning out."

_____a. Entire twig, cane or shoot is removed.
_____b. Prevents the development of lateral buds.
_____c. Induces open or rangy type growth.

10. List three general rules for pruning.

11. List five pruning tools.

ANSWERS TO UNIT TEST:

1. a. (3)
   b. (1)
   c. (5)
   d. (2)
   e. (4)
   f. (7)
   g. (6)
   h. (8)

2. a,c,e,f

3. List any three of the following:
   *To remove diseased or dead limbs
   *To restrict or promote growth
   *To encourage or improve blooming
   *To develop certain forms of growth

4. a. Pruning the stem
   b. Pruning the root

5. a. (T)
   b. (F)
   c. (T)
   d. (F)
   e. (T)
   f. (T)

6. a. (T)
   b. (T)
   c. (F)
   d. (T)
   e. (T)
   f. (F)

7. a. Heading back
   b. Thinning out

8. a,c,d

9. a,c

10. List any of the following rules using your own wording, subject to the instructor's approval.
    a. Use only sharp and proper tools for the job.
    b. Prune back to an existing bud or to a side branch.
    c. Cut larger limbs in three steps:
       1. Undercut.
       2. Cut into top.
       3. Cut stump off flush with trunk and paint with tree paint.
    d. Pruning in the summer months results in a greater dwarfing of trees than pruning in later winter months.
    e. Buy and plant trees and shrubs that have the characteristics, mature size, and shape you want. Do not count on pruning to keep tall plants short and spreading plants narrow.

11. List any five of the following:
    *Thumb and forefingers
    *Border shears
    *Grass shears
    *Lopping shears
    *Pruning shears
    *Hedge shears
    *Pruning saws
    *Pole pruners
    *Pole saws

Fruit Tree Pruning

I. Terms and Definitions.

A. Pome fruits - Apple and Pear
B. Drupe fruits - Peach, Apricot, Almond, Plum, and Cherry.
C. Fruiting wood - The part of a branch that produces the fruit.
D. Lateral - Branches that are horizontal to the ground.
E. Crotch - Where two branches come together to form a "Y."
F. Headed back - Terminal portion of twigs, canes, or shoots are removed.
G. Thinned out - Entire twig, cane, or shoot is removed.

II. Facts About the Method of Pruning Called "Training."

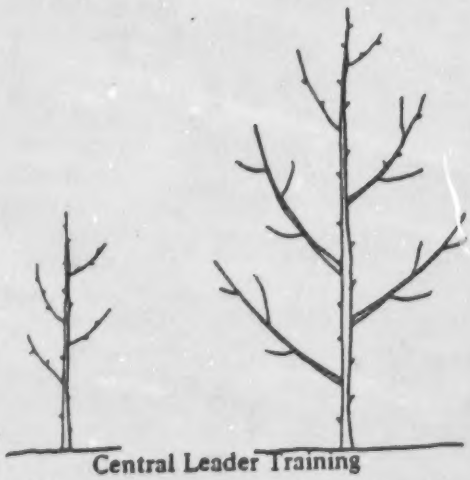
A. This method of pruning is used in many tree-fruit industries.
B. It is a form of top prunning.
C. Training enables young trees to develop a frame of scaffold limbs sufficiently strong to bear large crops of fruit without breaking.
D. Training enables trees to develop strong crotches which prevent splitting.
E. Even light training of young trees lengthens the time from planting to flowering and fruiting.
F. Training shoud be efficiently performed by knowledgeable people.

III. Various Forms to Which Fruit Trees are Trained (See Illustration under IV, V, VI).

A. Central Leader.
B. Open center or vase.
C. Modified Leader.

IV. Facts About Central Leader Type of Training.

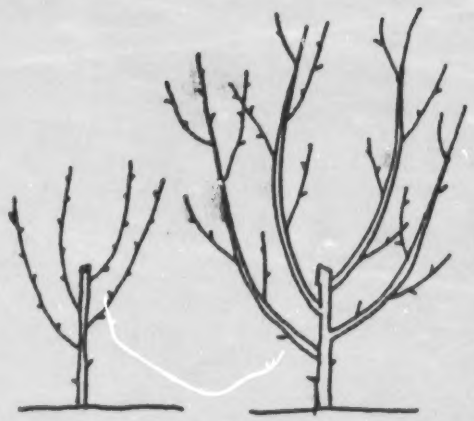
A. Has a main branch and a series of well-spaced "subordinate" lateral branches.
B. Develops strong crotches at the junction of the limb and the trunk.
C. The shading of the interior of the tree weakens the central leader and shortens the life of the tree.
D. Some varieties are trained easily to this form (Wealthy, Apple, Pecan); others are trained with difficulty (Rhode Island Greening Apple).



Central Leader Training

V. Facts About Open Center or Vase Type of Training.

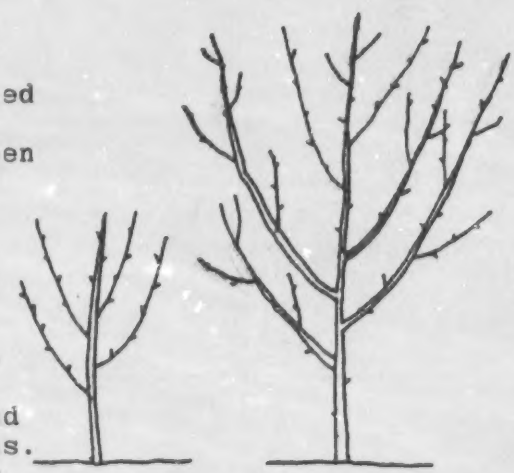
A. Has no main or central branch.
B. Has a series of well-spaced coordinate lateral branches.
C. Laterals are cut back equally each year. All laterals are of the same size and produce generally the same number of leaves.
D. Light penetration is sufficient for the fruiting of inner branches.
E. The low-headed tree, which develops, facilitates pruning, thinning, spraying, and picking operations.
F. Tree develops weak, crowded crotches which frequently break under severe stresses.
G. Examples: Apricot, Peach.



Open Center or Vase Training

VI. Facts About the Modified Type of Training.

A. Between central-leader and open-center type of tree training.
B. Cental leader is cut back and not allowed to become dominant.
C. The process of cutting back and selecting lateral is repeated until the proper number and distribution of branches has been obtained.
D. The central leader is then discontinued and the tree assumes a more or less rounded, open top.
E. This type of tree has low and well-spaced limbs, well-distributed fruiting wood, and is sufficiently close to the ground to facilitate orchard operations.
F. This type of tree form combines the most important advantages of the other types.



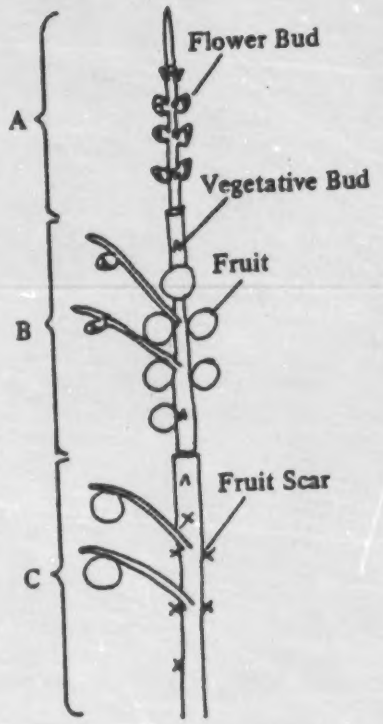
Modified Training

VII. Facts About Prunning Pome Trees.

A. A working knowledge of the flowering and fruiting habits of pome fruit trees is essential to understanding pruning requirements.
B. Pome fruits are produced on short lateral branches called fruiting spurs.

VIII. Facts About the Development of Fruiting Spurs.

A. Certain laterally situated vegetative buds on the second season's wood make a short growth usually 1/2 to 3 inches.
B. The following spring each bud develops into a cluster of flowers, makes a short vegetative growth, and develops one or more fruits (third year wood).
C. During the third spring a laterally situated vegetative bud on any given individual spur makes a short growth, and in late summer it develops a terminally situated bud.
D. This sequence continues throughout the life of any given spur.
E. Ideally the individual spur lays down a bud one year and produces fruit the next year.



IX. Different Periods in the Life of Pome Fruit Trees.

A. Vegetative Period - One to Four years.
B. Transitory Period - Five to Eight years.
C. Fruiting Period - Eight to Forty years.

X. Pruning During the Vegetative Period.

A. Head back to promote the development of lateral branches and low-headed trees.
B. Select well-spaced laterals to form the framework, and remove the others.
C. Prune the remaining limbs to regulate their growth without interference.

XI. Pruning During the Transitory Period.

A. Fruit trees change from vegetative phase to alternating vegetative-reproductive phase during this period.
B. Prune lightly.
C. Remove dead or diseased limbs.
D. Lightly thin out the top.

XII. Pruning During the Fruiting Period.

A. During the early stage of this period, young trees are vigorous and need only corrective pruning.
B. Corrective pruning consists of removing dead and diseased limbs and undesirable parallel branches.
C. During the later stages of this period, older trees develop small, weak branches that produce small, poor-quality fruit.
D. Pruning consists of removing all branches that are less than 1/2" in diameter.
E. Branches to be pruned are generally found on the inside of the trees.

XIII. Facts About Drupe Fruit Trees (Peach, Apricot, Almond).

A. The fruit of the peach, apricot, and almond is borne on the second season's wood which is itself developed during the previous season.
B. During the first part of the first season, this wood, called shoots, grows in length, and during the latter part it develops flower buds (See TM 2).
C. There is a close relationship between vigor of shoot-growth to the productivity of the following year.

1. Weakly vigorous (3-6-8 inches) - Few flower buds.
2. Moderately vigorous (6-12-18 inches) - Large number of flower buds.
3. Excessively vigorous (18-24-36 inches) - Relatively few flower buds.

D. Obviously, the moderately vigorous wood is the most productive.

XIV. Facts About Drupe Fruit Trees (Cherry and Plum).

A. The fruit of the plum and cherry is produced from simple laterally situated buds.
B. The buds are laid down on the current season's growth and on spurs.
C. Vegetative buds always terminate shoot and spur growth.
D. Moderate vigorous wood is the most productive.

XV. Facts About Drupe Fruit Tree (Peach) Vegetative Period (First 2-3 years).

A. Trained to the open-center form.
B. In the spring, the newly planted tree is headed back to a lateral branch or bud 24 to 36 inches from the ground line.
C. Lateral branches are allowed to grow for two to three years before the scaffold limbs are selected.
D. Very little pruning is required the first few years except for broken, diseased, or out-of-place branches.
E. After the tree has grown for two or three years, three to five lateral branches (perferably four) are selected.
F. These should be arranged spirally around the trunk four to six inches apart, and are called the main scaffold limbs of the tree.
G. The secondary laterals in the center of the tree are removed or cut back to a lateral branch.
H. Open-center type of tree is developed, which exposes the leaves to full sunlight and facilitates orchard operations.

XVI. Facts About Drupe Fruit Tree (Peach) Transistory Period (3-4 years).

A. Moderate pruning is necessary.
B. If any branch becomes dominant, it is cut back to an outside lateral branch.
C. The branches in the center portion are pruned to maintain the open-center type.
D. The objectives are to maintain strong, evenly distributed scaffold limbs, to expose all parts of the tree to adequate sunlight, and to maintain a relatively low-headed tree with well distributed fruiting wood.

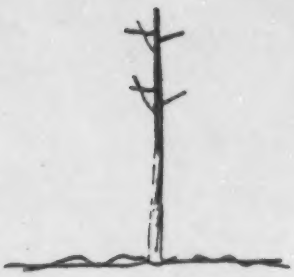
XVII. Facts About Drupe Fruit Tree (Peach) Fruiting Period (5-20 years).

A. Object is to maintain a moderately vigorous condition (See XII).
B. In addition, remove four or five shoots at the terminal of each branch and head back the remainder of the current season's growth of each branch.

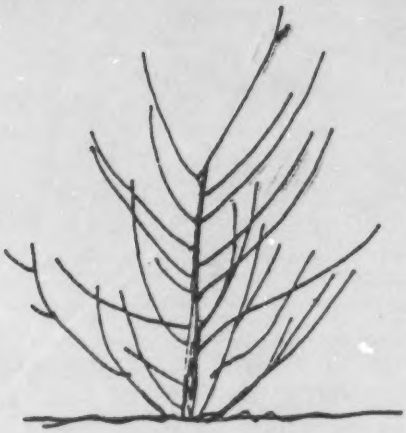
XVIII. Facts About Drupe Fruit Trees (Cherry and Plum). All Periods.

A. Trained to the modified-leader tree form.
B. Select three or four laterals and a leader.
C. Laterals should be at least 4 to 6 inches apart and arranged around a main stem to prevent girdling of the trunk.
D. During the transitory period, light pruning, mostly of the thinning-out type, is necessary.
E. With upright-growing varieties attention is given to the development of lateral branches.
F. During the bearing period the amount of thinning out and heading back varies with the species.
G. Cherries require the least pruning, since direct light is unnecessary for the development of the fruit - crop is seldom heavier than the tree can bear.
H. The European plum requires more pruning than the cherry, but less than the Japanese plum, which requires less than the peach.
I. In any case, old trees are pruned more severely than young trees in order to renew the fruiting wood.

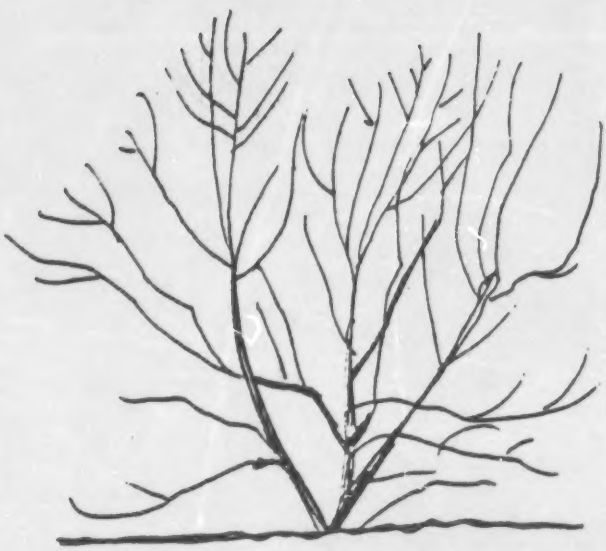
Training of a Young Peach Tree



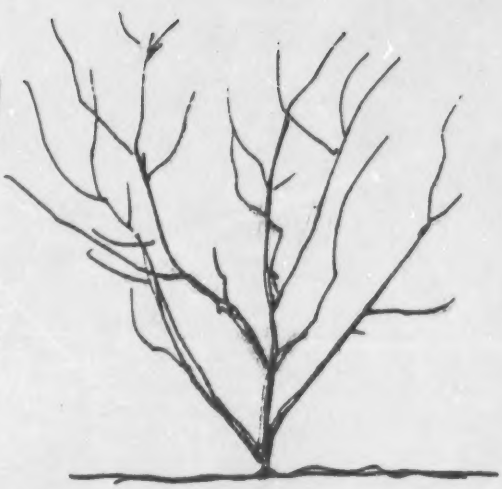
1. Plant



2. Vegetative Period



3. Transitory Period



4. Fruiting Period

UNIT TEST:

1. Match:

_____a.	Thinned out	(1)	Where two branches come together to form a "Y."
_____b.	Lateral	(2)	Entire twig, cane, or shoot is removed.
_____c.	Crotch	(3)	Apple and pear.
_____d.	Pome fruits	(4)	The part of the branch that produces fruit.
_____e.	Fruiting wood	(5)	Peach, apricot, almond, plum, and cherry.
_____f.	Drupe fruit	(6)	Terminal portion of twigs, canes or shoots are removed.
_____g.	Headed back	(7)	Branches that are horizontal to the ground.

2. Choose from the following statements those that pertain to the pruning method called training.

_____a. This method of pruning is used in the many tree-fruit industries.
_____b. A form of top pruning.
_____c. Young trees develop a frame of scaffold limbs sufficiently strong to bear large crops of fruit without breaking.
_____d. Trees develop weak crotches.
_____e. Light pruning lengthens the time from planting to flowering and fruiting.
_____f. Anyone can prune trees, knowledge or no knowledge.

3. Name three forms to which fruit trees are trained.

4. Identify as True or False from the following statements those that pertain to the central leader type of training.

_____a. Has a main branch and a series of well-spaced "subordinate" lateral branches.
_____b. Develops strong crotches due to the interlacing of fibers at the junction of the limb and the trunk.
_____c. The shading of the interior of the tree strengthens the central leader of the tree.
_____d. All varieties are difficult to train to this form.

5. Identify as True or False from the following statements those facts that pertain to the open center or vase type of training.

_____a. Has no main or central branch.
_____b. Has a series of well-spaced coordinate lateral branches.
_____c. Laterals are cut back unequally each year.
_____d. Light penetration is sufficient for the fruiting of inner branches.
_____e. A low-headed tree develops.
_____f. Tree develops weak, crowded crotches which frequently break under severe stresses.

6. Choose from the following statements those that pertain to the modified type of training.

_____a. Happy medium between central leader and open center type of tree training.
_____b. Central leader is cut back and not allowed to become dominant.
_____c. The process of cutting back and selecting laterals is repeated until the proper number and distribution of branches have been obtained.
_____d. The central leader is then continued.
_____e. This type of tree is tall and rangy.
_____f. This type of tree has well-spaced limbs.

7. State two facts about the pome fruits.

8. Choose from the following statements those that pertain to the development of fruiting spurs.

_____a. Certain laterally situated vegetative buds on the second season's wood make a short growth usually 1/2 to 3 inches or more, and in the late summer they develop a terminally situated mixed bud.
_____b. It takes two seasons for the mixed bud to develop.
_____c. During the third spring a laterally situated vegetative bud on any given individual spur makes a short growth, and in late summer it develops a terminally situated mixed bud.
_____d. This sequence continues throughout the life of any given spur.
_____e. Ideally the individual spur lays down amixed bud one year and produces fruit the next year.

9. Name the different periods in the life of pome fruit trees.

10. Identify as True or False the following statements about pruning during the vegetative period.

_____a. Heading back to promote the development of lateral branches and low-headed tree.
_____b. Selecting well-spaced laterals to form the framework and removing the others.
_____c. Pruning the remaining limbs to regulate their growth and without interference.

11. Select as True or False the following statements about pruning during the transitory period.

_____a. Fruit trees change from vegetative phase to alternating vegetative-reproductive phase.
_____b. Fruit trees are pruned heavily.
_____c. Remove dead or diseased limbs.
_____d. Lightly thin out the top.

12. Select as True or False the following statements about pruning during the fruiting period.

_____a. Early stage of this period, the young trees are vigorous and only corrective pruning is needed.
_____b. Corrective pruning consists of removing dead and diseased limbs and undesirable parallel branches.
_____c. The later stages of this period, the older trees develop small weak branches that produce small, poor quality fruit.
_____d. Pruning consists of removing all branches that are more than 1/2 inch in diameter.
_____e. These branches are generally found on the inside of the trees.

13. Choose from the following statements those that pertain to drupe fruit trees (Peach, Apricot, Almond).

_____a. The fruit of the peach, apricot, and almond is borne on the second season's wood which is itself developed during the previous season.
_____b. Shoots and flower buds are not produced during the same season.
_____c. There is a close relation of vigor of shoot growth to productivity the following year.
_____d. Vigorous wood is the most productive.

14. Choose from the following statements those that pertain to drupe fruit trees (Cherry and Plum).

_____a. The fruit is produced from simple laterally situated buds.
_____b. The buds are laid down on the current season's growth on spurs.
_____c. Vegetative buds always terminate shoot and spur growth.
_____d. Moderate vigorous wood is not the most productive.

15. Select from the following statements those that pertain to a drupe fruit tree (Peach) vegetative period.

_____a. Trained to the open-center form.
_____b. In the spring, the newly planted tree is headed back to a lateral branch or bud 24 to 36 inches from the ground line.
_____c. Lateral branches are allowed to grow for two to three years before the scaffold limbs are selected.
_____d. Heavy pruning is required the first few years.
_____e. After the tree has grown two to three years, three to five lateral branches are selected.
_____f. The lateral branches are arranged in stair steps up the side of the tree.
_____g. The secondary laterals in the center of the tree are removed or cut back to a lateral branch.
_____h. Open-center type of tree is developed, which exposes the leaves to full sunlight and facilitates orchard operation.

16. Select from the following statements those that pertain to a drupe fruit tree (Peach) transitory period.

_____a. Moderate pruning is necessary.
_____b. If any branch becomes dominant, it is removed.
_____c. The branches in the center are never removed.
_____d. One objective is to maintain strong, evenly distributed scaffold limbs.
_____e. Another objective is to maintain a relatively low-headed tree with well-distributed fruiting wood.

17. Select from the following statements those that pertain to a drupe fruit tree (Peach) fruiting period.

_____a. Main object is to maintain a moderately vigorous condition.
_____b. Remove four or five shoots at the terminal of each branch each year.
_____c. Never do any heading back of the current season's growth.

18. State four facts about drupe fruit tree (cherry or plum) in your own words.

ANSWERS TO UNIT TEST:

1. a. (2) c. (1) e. (4)
   b. (7) d. (3) f. (5)
   g. (6)

2. a,b,c,e

3. a. central leader
   b. open center or vase
   c. modified leader

4. a. (T) c. (F)
   b. (T) d. (F)

5. a. (T) c. (F) e. (T)
   b. (T) d. (T) f. (T)

6. a,b,c,f

7. a. A working knowledge of flowering and fruiting habits is essential to understanding of pruning requirements.
   b. Pome fruits are produced from mixed buds which are borne on short lateral branches called fruiting spurs.

8. a,c,d,e

9. a. vegetative period b. tansitory period
   c. fruiting period

10. a. (T) b. (T) c. (T)

11. a. (T) b. (F) c. (T) d. (T)

12. a. (T) b. (T) c. (T)
    d. (F) e. (T)

13. a,c,d

14. a,b,c

15. a,b,c,e,g,h

16. a,b,d,e

17. a,b

18. (Any four of the following, any order, any wording okay if instructor approves)

    *Trained to the modified-leader tree form.
    *Select three or four laterals and a leader.
    *Laterals should be at least 4 to 6 inches apart and arranged around a main stem to prevent girdling of the trunk.
    *During the transitory period, light pruning, mostly of the thinning-out type, is necessary.
    *With upright-growing varieties attention is given to the development of lateral branches.

*During the bearing period, the amount of thinning out and heading back varies with the species.
*Cherries require the least pruning, since direct light is unnecessary for the development of the fruit - crop is seldom heavier than the tree can bear.
*The European plum requires more pruning than the cherry, but less than the Japanese plum, which requires less than the peach.
*In any case, old trees are pruned more severely than young trees in order to renew the fruiting wood.

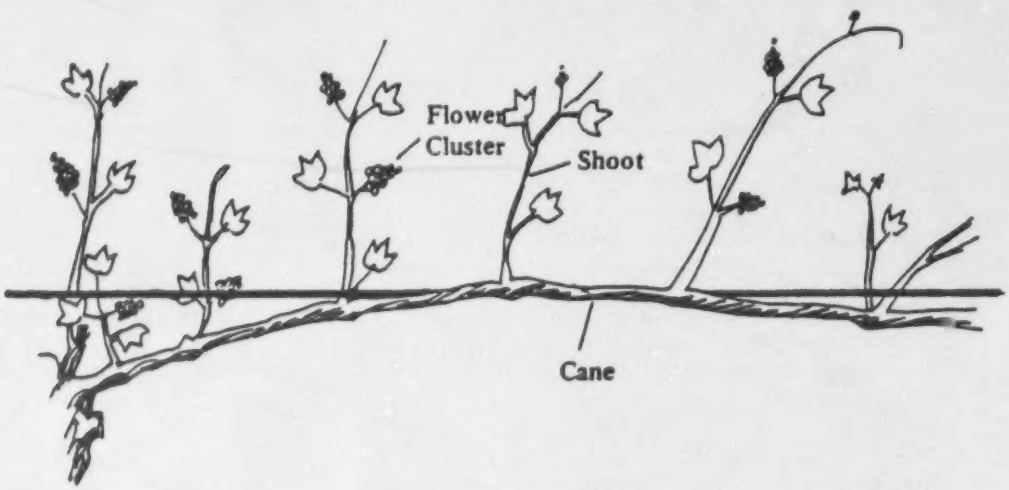
Grape and Berry Pruning

I. Terms and Definitions.

A. Lateral - Branches that are horizontal to the ground.
B. Headed back - Terminal portion of twigs, canes, or shoots are removed.
C. Thinning out - Entire twig, cane, or shoot is removed.
D. Fruit spurs - Stubby fruit-bearing twigs up to three inches long.
E. Cane - A stem of various fruits, such as the raspberry or blackberry.

II. Fruiting Habits of the Grape.

A. The fruit of the grape comes from buds which are borne on one-year-old shoots called canes, which are developed during the previous season.
B. Fruiting of the grape is positively associated with vigor of the cane.
C. Medium-thick (moderately vegetative) canes are more fruitful than thin (weakly vegetative) or thick (vigorously vegetative) canes.
D. Size of cane is important consideration in productivity.



III. Pruning the Young Vine (first through third year).

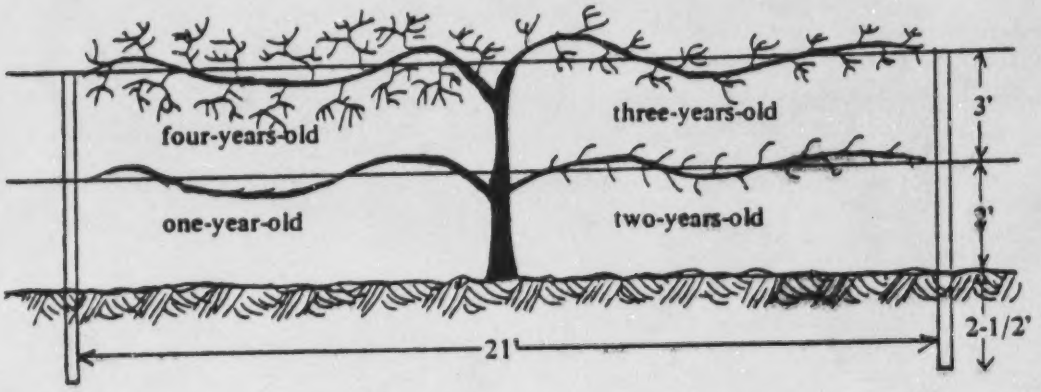
A. Cut back the most vigorous cane to two or three buds and remove the remaining buds.
B. Set the plant in the vineyard.
C. Tie the canes to a stake to permit close cultivation during the growing season.
D. Cut back the most vigorous cane to two or three buds and remove the remainder during the dormant season.
E. After the next season the vines are trained to the system desired.

IV. Various Systems of Training and Pruning Grapes (See TM 1).

A. The six-arm.
B. The fan.
C. Wire canopy or overhead.
D. Single trunk and arm (the Kniffen System) - the most commonly used.

V. Facts About the Single Trunk and Arm-System (Kniffen) of Training and Pruning Grapes.

A. This system consists of a permanent trunk with lateral branches called arms.
B. This length and number of arms depend largely on the size of the individual fruit clusters produced, and this in turn depends on the kind of grape grown.



VI. Fruiting Habits of the Brambleberries (Black, Purple, and Red Raspberry; also Blackberry and Dewberry).

A. Like the grape, the fruit of the brambleberries develops from buds borne on one-year-old canes.
B. The canes develop the first season, fruit, and then die the second season (except the everbeating raspberries and the Himalaya blackberries).
C. Pruning of the canes before they have fruited depends on the variety and method of training.

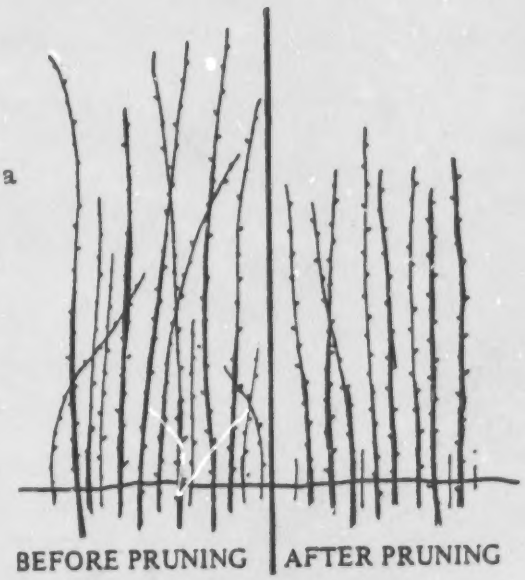
VII. Facts About Black and Purple Raspberries.

A. Usually set more fruit than the canes can actually develop.
B. Must be heavily pruned, according to variety, and training.
C. Tips of young shoots of the black varieties are "pinched off" when they are from 12 to 18 inches high.
D. Purple varieties are "pinched off" when they are from 30 to 36 inches high.
E. The pinching off induces the development of lateral branches and prevents the canes from becoming top heavy.
F. Just before growth starts in the spring the laterals are headed back.

BEFORE PRUNING AFTER PRUNING

VIII. Facts About the Red Raspberry.

A. Produces tall, erect stems.
B. Remove canes that have fruited.
C. Thin out all small and extra canes.
D. Times of pruning vary with localities. See your local county agent.



BEFORE PRUNING | AFTER PRUNING

IX. Facts About Blackberries.

A. One type - called erect (pruned and trained like the red raspberry).
B. Other type - called trailing (trained to stakes or on horizontal or vertical trellises).
   1. Cut out canes that have fruited.
   2. Thin out number of canes per plant to facilitate larger berries.
   3. This results in the production of vigorous canes the following year.

X. Facts About Dewberries.

A. Are either trained on trellises, on stakes, or are allowed to grow on the surface of the land.
B. All canes, both young and old, are removed after the harvest, and the canes that develop later are used for next year's crop.

XI. Facts About Blueberries.

A. The blueberry produces fruit on one-year-old wood.
B. Without pruning most varieties tend to overbear and produce small fruit.
C. The largest fruit is produced on the most vigorous wood.
D. Remove weak, slender, small branches, and cut back the fruiting branches.

E. The amount of heading back depends on the variety and the growing conditions.
F. Very little pruning is required the first two years.

XII. Facts About Currants and Gooseberries.

A. They form many stems and without pruning they become dense and unproductive.
B. Fruit is borne on one-year-old branches, and on one-year-old spurs of two and three-year-old branches.
C. Pruning consists of removing the three-year-old branches.
D. The branches seldom need heading back.

UNIT TEST:

1. Match

_____a.	Headed back	(1)	A stem of various fruits, such as the raspberry or blackberry.
_____b.	Thinned out	(2)	Branches tnat are horizontal to the ground.
_____c.	Fruit spurs	(3)	Entire twig, cane or shoot is removed.
_____d.	Lateral	(4)	Stubby fruit-bearing twigs up to three inches.
_____e.	Cane	(5)	Terminal portion of twigs, canes, or shoots is removed.

2. Choose from the following statements those that pertain to the fruiting habits of grapes.

_____a. The fruit of the grape comes from mixed buds.
_____b. Fruiting of the grape is positively associated with vigor of the cane.
_____c. The cane is a stake that holds up the grapevine.
_____d. Medium-thick (moderately vegetative) canes are more fruitful than thin (weakly vegetative) or thick (vigorously vegetative) canes.
_____e. Size of cane is not an important consideration in productivity.

3. List in sequence the steps in pruning a young grapevine.

4. State the four systems of training and pruning grapes.

5. Identify as True or False the following statements concerning the single trunk and arm system of training and pruning the grape.

_____a. Consists of a single, permanent trunk with lateral branches called arms.
_____b. The length and number of arms depend largely on the size of the individual fruit clusters produced.
_____c. The length and number of arms does not depend on the size of the fruit clusters.

6. Select from the following statements those that pertain to the fruiting habits of brambleberries.

a. The fruit of the brambleberries develops from mixed buds borne on one-year-old canes.
b. The canes develop the first season, fruit, and then die the second season.
c. Pruning of the canes before they have fruited does not depend on the variety.

7. Identify as True or False the following statements concerning the black and purple raspberry.

_____a. Usually set more fruit than the canes can adequately develop.
_____b. Must be heavily pruned, according to variety, and training.
_____c. Never "pinch-off" the young shoots.
_____d. The pinching off induces the development of lateral branches and prevents the canes from becoming top heavy.
_____e. Laterals are headed back in the spring.

8. Select from the following statements those that pertain to the red raspberry.

_____a. Produces tall, erect stems.
_____b. Canes should not be removed after they have fruited.
_____c. All small and extra canes are thinned out.
_____d. Different times of pruning varies with localities.

9. List the two types of blackberry training.

10. Choose from the following statements those that pertain to dewberries.

_____a. Either trained on trellises or on stakes.
_____b. Never are allowed to grow on the ground.
_____c. All canes are removed after the harvest.
_____d. The canes that develop after harvest are used for next year's crop.

11. State three facts concerning blueberries.

12. Select as True or False the following statements that pertain to currants and gooseberries.

_____a. They form many stems and without pruning they become dense and unproductive.
_____b. Fruit is borne only on three-year-old branches.
_____c. Pruning consists of removing three-year-old branches.
_____d. The branches seldom need heading back.

ANSWERS TO UNIT TEST:

1. a. (5)
   b. (3)
   c. (4)
   d. (2)
   e. (1)

2. a,b,d

3. a. Cut back the most vigorous cane to two or three buds and remove the remaining buds.
   b. Set the plant in the vineyard.
   c. Tie the canes to a stake to permit close cultivation during the growing season.
   d. Cut back the most vigorous cane to two or three buds and remove the remainder during the dormant season.
   e. After the next season the vines are trained to the system desired.

4. a. Six-arm
   b. Fan
   c. Wire canopy or overhead
   d. Single trunk and arm

5. a. (T) b. (T) c. (F)

6. a,b

7. a. (T)
   b. (T)
   c. (F)
   d. (T)
   e. (T)

8. a,c,d

9. a. Erect b. Trailing

10. a,c,d

11. List in your own words any of the following three facts:

*The blueberry produces fruit on one-year-old wood.
*Without pruning most varieties tend to overbear and produce small fruit.
*The largest fruit is produced on the most vigorous wood.
*Remove weak, slender, small branches, and cut back the fruiting branches.
*The amount of heading back depends on the variety and the growing conditions.
*Very little pruning is required the first two years.

12. a. (T)
    b. (F)
    c. (T)
    d. (T)

Rose Pruning

I. Terms and Definitions.

A. Pruning compound - A commercial, chemical compound used to seal open cuts to prevent diseases to enter the plant.
B. Sucker - Shoots that emerge below the graft.
C. Headed back - Terminal portion of twigs, canes or shoots that are removed.
D. Thinned out - Entire twig, cane, or shoot is removed.
E. Candelabra - Side branches that eventually turn upward.

II. General Pruning Rules for All Roses.

A. Remove dead canes and twigs.
B. Remove crossing branches and suckers.
C. Renew plant by removing an old cane for each new one.
D. Use sharp shears for clean cuts.
E. Seal large cuts with a pruning compound.

III. General Pruning Rules for Mature Roses.

A. Cut 1/3 to 1/5 of oldest canes back to base of the plant.
B. Save young vigorous canes.
C. Cut back to two or three buds on all of the side branches.
D. Severity of pruning depends on the kind of rose grown and the size of flower desired.
E. Weak stems are thinned out.
F. Sturdy stems are headed back to varying heights depending on their vigor.
G. All cuts are made to an outer bud to promote spreading of the plant.

IV. When to Prune Roses.

A. Prune at end of dormant season when leaf buds are beginning to swell.
B. Times vary with locality.
C. Annual pruning is made simpler if you've kept roses picked and trimmed all year.
D. Each class of rose has its own pruning requirements.

V. Procedures for Pruning Low Growing Roses.

A. Head back slightly.
B. Remove dead or diseased branches.
C. Examples: Polyantha, Dwarf, Midget.

VI. Procedures for Pruning Tall Growing Roses.

A. Prune for form.
B. Removes spent clusters of a strong bud.
C. Head back about 1/4 of last year's growth.
D. Shape plant as you prune.
E. Examples: Polyantha, Floribunda.

VII. Procedures for Pruning All Hybrid Teas.

A. Head back to about 1/2 of last year's growth.
B. Use general rules in section II and III of this unit.

VIII. Procedures of Pruning Hybrid Teas (taller varieties).

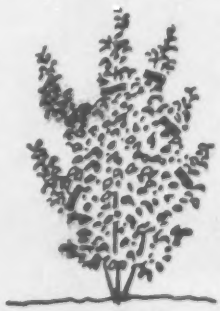
A. Do not remove more strong wood than necessary.
B. Cut 60 inch growth to 30 inches.
C. Use general rules in section II and III of this unit.

IX. Procedures for Pruning Climbing Hybrid Teas.

A. Grow for two years before pruning.
B. Little pruning necessary.
C. Prune immediately after blooming.
D. Removedead and diseased branches.

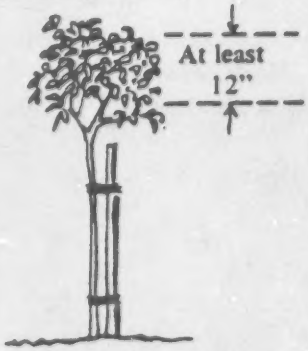
X. Procedures for Pruning Pillar and Tall Shrubbery Roses.

A. Keep heavy canes thinned out.
B. Remove candelabras.
C. Head back for desired shape and height.



XI. Procedures for Pruning Tree Roses.

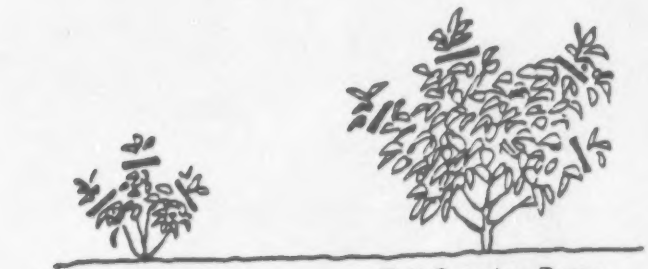
A. Remove branches of main trunk until the desired height is reached.
B. Always keep vegetative top of tree to a minimum of twelve inches.
C. Shape plant when flowers are cut.
D. Keep as many older branches as needed to maintain symmetrical balance.



XII. Some General Information About Roses.

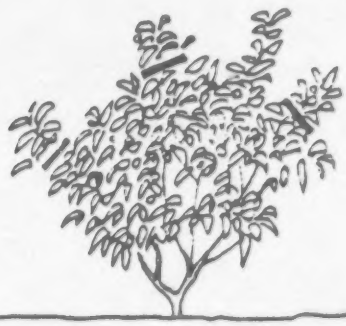
A. Stems that produced flowers are removed to facilitate the development of new shoots which produce flowers the following year.
B. Ramblers require a small amount of heading back and removal of dead and weak wood.
C. Rugosa types require the removal of old, weak, dead, or diseased wood only.
D. Pruning tools should be disinfected after use on dead or diseased wood.

General Rules for Rose Pruning



Low Growing Roses

Tall Growing Roses

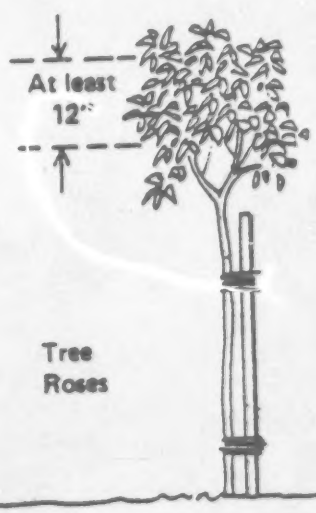


Hybrid Teas

Taller Hybrid Teas

Climbing Hybrid Teas

Pillar and
Tall Shrubbery
Roses



Tree
Roses

UNIT TEST:

1. Write definitions for the following terms (any wording okay, if instructor approves).

   a. Sucker

   b. Headed back

   c. Pruning compound

   d. Thinned out

   e. Candelabra

2. List at least three general rules for pruning roses.

3. Choose the correct statements that pertain to rules for pruning mature rose plants.

   _____a. Cut 1/3 to 1/5 of oldest canes back to base of plant.
   _____b. Do not save vigorous canes.
   _____c. Cut back to two or three buds on all of the side branches.
   _____d. Severity of pruning depends on the kind of rose grown and the size on their vigor.
   _____e. Weak stems are encouraged to grow.
   _____f. Sturdy stems are headed back to varying heights depending on their vigor.
   _____g. All cuts are made to outer bud to promote spreading of the plant.

4. State three general rules about when to prune roses.

5. Name two procedures in pruning low growing polyanthas, dwarfs, and midget roses.

6. Select the correct statements that pertain to procedures for pruning taller growing polyanthas and floribundas.

   _____a. Prune for form.
   _____b. Remove clusters to a strong bud.
   _____c. Head back about 1/4 of last year's growth.
   _____d. Do not shape plant as you prune.

7. Choose the correct statements that pertain to procedures for pruning hybrid teas.

   _____a. Head back to about 1/2 of last year's growth.
   _____b. Do not remove dead canes and twigs.
   _____c. Use sharp shears for clean cuts.
   _____d. Seal large cuts with pruning compound.

8. Select the correct statements that pertain to procedures for pruning the taller varieties of hybrid teas.

_____a. Do not remove more strong wood than necessary.
_____b. Cut 60 inch growth to 30 inches.
_____c. All cuts are made to an outer bud to promote spreading of the plant.
_____d. All statements above are correct.

9. Identify as True or False those statements that pertain to procedures for pruning climbing hybrid teas.

_____a. Grow for six years before pruning.
_____b. Little pruning is necessary.
_____c. Prune immediately after blooming.
_____d. Remove dead and diseased branches.

10. Identify as True or False those statements that pertain to procedures for pruning pillar and tall shrubbery roses.

_____a. Remove candelabras.
_____b. Keep heavy canes thinned out.
_____c. No shaping is necessary.

11. Select from the following statements those that pertain to pruning tree roses.

_ __a. Remove branches of main trunk until the desired height is reached.
_____b. There is no minimum on the size of the vegetative top of the plant.
_____c. Do not cut the flowers because the shape of the tree would not have the right form.
_____d. Keep as many older branches as needed to maintain symmetrical balance.

12. Select from the following statements those that are true of rose pruning.

_____a. Stems that produced flowers are removed to facilitate the development of new shoots which produce flowers the following year.
_____b. Ramblers need severe pruning.
_____c. Rugosa types require the removal of old, weak, dead, or diseased wood only.

ANSWERS TO UNIT TEST:

1. (Different wording okay, if instructor approves.)

   a. Shoots that emerge below the graft.
   b. Terminal portion of twigs, canes or shoots that are removed.
   c. A commercial, chemical, compound used to seal open cuts to prevent diseases.
   d. Entire twig, cane, or shoot is removed.

2. (Any three of the following: any order: different wording okay, if instructor approves.)

   *Remove dead canes and twigs.
   *Remove crossing branches and suckers.
   *Renew plant by removing an old cane for each new one.
   *Use sharp shears for clean cuts.
   *Seal large cuts with pruning compound.

3. a,c,d,f,g

4. (Different wording okay, if instructor approves.)

   a. End of dormant period.
   b. Proper time for locality.
   c. Keep roses picked and trimmed at all times.
   d. Different types of roses have different times for pruning and requirements.

5. a. Head back slightly.
   b. Remove dead and diseased branches.

6. a,b,c

7. a,c,d

8. a,b,c,d

9. a. (F)
   b. (T)
   c. (T)
   d. (T)

10. a. (T)
    b. (T)
    c. (F)

11. a,d

12. a,c

Ornamental Vine Pruning

I. Terms and Definitions.

A. Tendrils - Modified leaf.
B. Dowel - Round wooden rod.
C. Variegated - Several colors.

II. Some General Facts About Ornamental Vines.

A. All vines require some kind of support.
B. Most vines require some pruning to prevent tangling.
C. Most vines require some pruning to get good coverage for the area.
D. Some vines require no pruning except to remove dead and injured tendrils and branches.
E. Some vines are produced for vegetables, flowers for cutting, or flowers for display.
F. Some vines are produced for their striking foliage, both evergreen and deciduous.
G. Some vines are produced for their fruit, such as the grape.

III. Some General Uses for Ornamental Vines.

A. In landscaping, vines are often usable in places where no other plants have room to grow, such as a long, blank, sunbaked wall with a walk beside it.
B. On a fence, a vine can give the effect of a hedge but requires less space and maintenance.
C. As a screen, a vine can hide unsightly views.

IV. Methods of Training Ornamental Vines.

A. Ornamental vines must be pruned (Use General Pruning Techniques. Introduction to Pruning page 37 of this Unit).

1. Vertical support: Example, morning glories, passion vines, sweat peas.
2. For fence support: attach vines to wood strips, secured with wire - any design can be achieved by pruning (head back and thin out).
3. For hinged trellises: vines attached to a framework that can be pulled back for painting wall.
4. For lattice screens: vines can be pruned to be wind-breaks and screens for privacy.
5. For vine-draped dowel: edge of caves can be softened by this method with proper pruning.

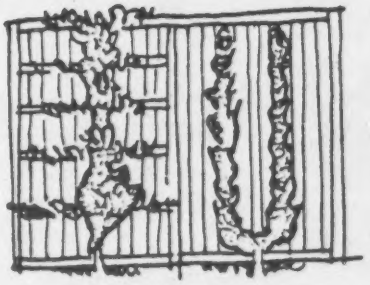
V. Some Woody Vines That Need Little Pruning.

A. English ivy.
B. Virginia creeper.
C. Bittersweet.

VI. Benefits of Fanning Vine Branches Horizontally.

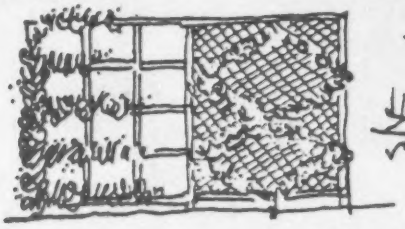
A. Lateral branches will be stimulated.
B. Heavier bloom will result.
C. Tangling will be avoided.
D. Top-heavy effect will be avoided.

Vertical Support

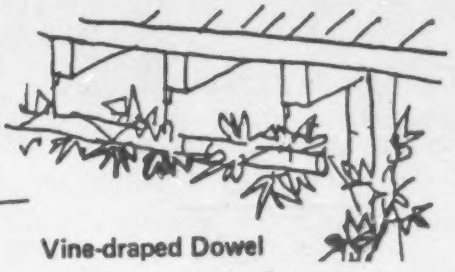


Fence Support

Hinged Trellis



Lattice Screen



Vine-draped Dowel

VII. Facts To Know Before Planting a Vine.

A. How fast will it grow?
B. How far will it grow?
C. For what purpose will it be used.
D. Type of support required.

VIII. Some Vines That Are Grown as Annuals.

A. Chayote (quick dense cover, squashlike edible fruit).
B. Moonflowers (many flowers).
C. Morning glory (many flowers).
D. Scarlet runner (massed red-orange flowers, edible beans).
E. Sweet pea (scented cut flowers).

IX. Some Vines That Are Grown for Flowers in Masses.

A. Bougainvillea
B. Burmese honeysuckle
C. Clematis
D. Hall's Japanese honeysuckle
E. Passion flower
F. Trumpet vines
G. Wisteria

X. Some Deciduous Vines.

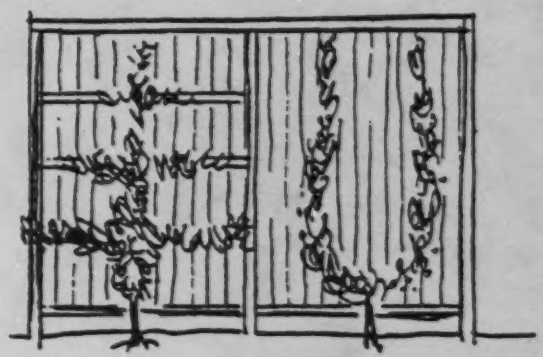
A. Bittersweet (attractive orange seeds).
B. Boston ivy (autumn color).
C. Grape (fruit).
D. Virginia creeper (autumn color).

XI. Some Evergreen Vines.

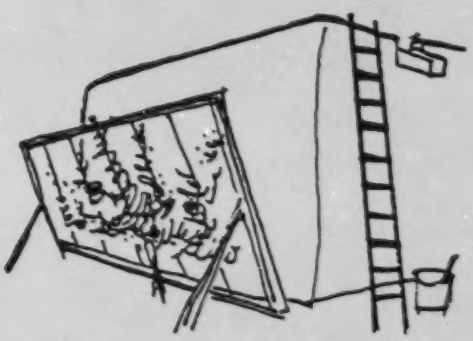
A. Algerian ivy (green or variegated).
B. Creeping fig.
C. English ivy (many leaf sizes and shapes).

Training Methods for Vines

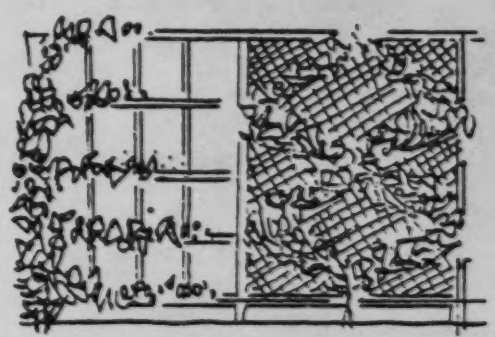
VERTICAL SUPPORT



FENCE SUPPORT



HINGED SUPPORT



LATTICE SCREEN

VINE-DRAPED DOWEL

UNIT TEST

1. Define the following terms:
   a. Tendrils
   b. Dowel
   c. Variegated
2. List four general facts about ornamental vines.
3. State three general uses for ornamental vines.
4. State four training methods for ornamental vines.
5. List three woody vines that need little pruning.
6. State four benefits of fanning out vine branches horizontally.
7. State four facts to know before planting a vine.
8. List three vines that are grown as annuals.
9. List four vines that are grown for flowers in masses.
10. List three deciduous vines.
11. List three evergreen vines.

ANSWERS TO UNIT TEST:

1. a. Modified leaf
   b. Round wooden rod
   c. Several colors

2. List any four of the following statements:
   *All vines require some kind of support.
   *Most vines require some pruning to prevent tangling.
   *Most vines require some pruning to get good coverage for the area.
   *Some vines require no pruning except to remove diseased and injured tendrils and branches.
   *Some vines are produced for vegetables, flowers for cutting, or flowers for display.
   *Some vines are produced for their striking foliage, both evergreen and deciduous.
   *Some vines are produced for their fruit, such as the grape.

3. a. For landscaping
   b. For a fence
   c. As a screen

4. List any four of the following:

   *Vertical support
   *Fence support
   *Hinged trellis
   *Lattice screens
   *Vine-draped dowel

5. a. English ivy
   b. Virginia creeper
   c. Bittersweet

6. a. Tangling will be avoided
   b. Lateral branches will be stimulated
   c. Top-heavy effect will be avoided.
   d. Heavier bloom will result

7. a. How fast will it grow?
   b. How far will it grow?
   c. For what purpose will it be used?
   d. Type of support required

8. List any three of the following:

   *Chayote
   *Moonflowers
   *Morning glory
   *Scarlet runner
   *Sweet pea

9. List any four of the following:

   *Bougainvillea
   *Burmese honeysuckle
   *Clematis
   *Hall's Japanese Honeysuckle
   *Passion flower
   *Trumpet vine
   *Wisteria

10. List any three of the following:

    *Bittersweet
    *Boston ivy
    *Grape
    *Virginia creeper

11. a. Algerian ivy
    b. Creeping fig
    c. English ivy

Ornamental Trees

I. Terms and Definitions:

A. Pleach - To interweave and plait branches of trees together to form a hedge or arbor.
B. Pollard - A tree from which the top has been sheared so that it puts out a dense head of slender shoots.
C. Deciduous tree - Trees that lose their leaves in the winter.
D. Coniferous tree - A tree that is evergreen. Covers two broad classes: one, those with branches that radiate out from the trunk in whorls; and those that grow branches in a random fashion.
E. Thinned out - With the entire branch, shoot, cane, or twig removed to the basal stem.
F. Headed back - With the end of a branch, shoot, cane, or twig removed.
G. Espalier - Describing a tree or shrub trained to grow flat against a wall or along a fence, wire, or trellis.
H. Topiary - Describing trees or shrubs sheared to geometric shapes, such as pyramids, spheres, cones, and other shapes.

II. Two General Reasons for Pruning Ornamental Trees.

A. To remove dead, diseased, or injured branches.
B. To keep the trees within the dimensions of the area.

III. General Rules for Removing Dead, Diseased, or Injured Branches (See TM 1).

A. Remove all stubs.
B. Sterilize all pruning tools after removing diseased branches (dip tools in a solution of 1/2 cup of clorox per one gallon of water).
C. Seal cuts to prevent disease and keep out rot.
D. Cut back frost-bitten wood a little at a time.

IV. General Rules for Keeping Trees Within Dimensions of an Area.

A. Deciduous trees:

1. Pinch out tips of branches at lower levels.
2. Remove lower branches in the third or forth year or when the head of the tree is large enough to take over growth.
3. Prune in late winter when the branches are bare.
4. Some trees can also be pinched back, cleaned up or sheared in the summer or fall.

B. Coniferous trees:

1. Conifers need to be pinched, headed back, and thinned out depending on type and variety.
2. Conifers - such as junipers - must be pruned regularly to keep them in bounds.
3. Prune generally just before Christmas.
4. Tree forms need less pruning than lower growing forms.
5. Some evergreens need heavy shearing in the spring - such as the arboviate.

V. Three Effects of Pruning Ornamental Trees.

A. Pruning to shape.
B. Pruning to strengthen trunk and branches.
C. Pruning for specific landscape use.

VI. Pruning to Shape (See TM 2).

A. To permit traffic to circulate under the tree.
B. To make various designs such as (See section on Special Purpose Pruning and Training):

1. An arbor by pleaching.
2. Espalier.
3. Topiary.
4. Pollard.

VII. Pruning To Strengthen Trunk and Branches.

A. Some trees grow too fast and produce long, soft, brittle growth that is easily damaged by wind and weight of water on the leaves.

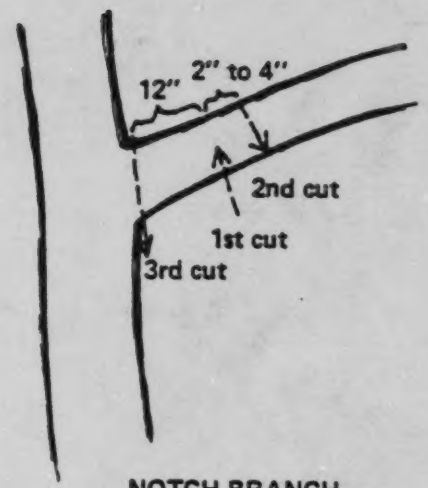
1. Cut back hard after the tree has been in the ground for at least a year and has developed a sturdy root system.
2. Cut to a side branch or bud, if possible.
3. New buds will form and branches will form from them.
4. Do this between March and August to allow growing time before freezes.
5. Later go back and take out all except one (or several) branches.

B. Some trees "weep" to the ground; must be trimmed to give aeration and strength to the tree.

VIII. Pruning for Specific Landscape Use.

A. To confirm with the area available.
B. To use the area to the best advantage.

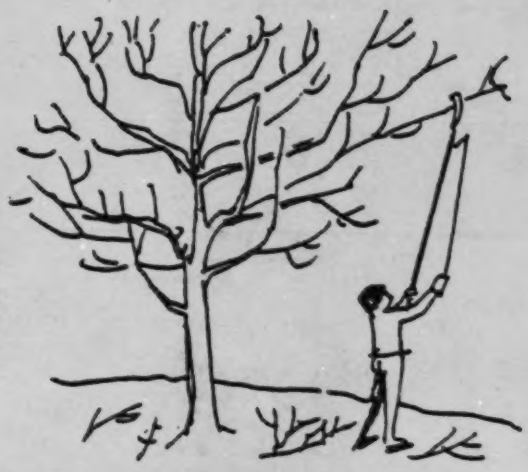
Removing Dead, Diseased, or Injured Branches



NOTCH BRANCH

SEAL CUTS

To prune frost-killed branch, cut off short pieces, stop at green wood.



USE POLE PRUNER

Pruning to Shape

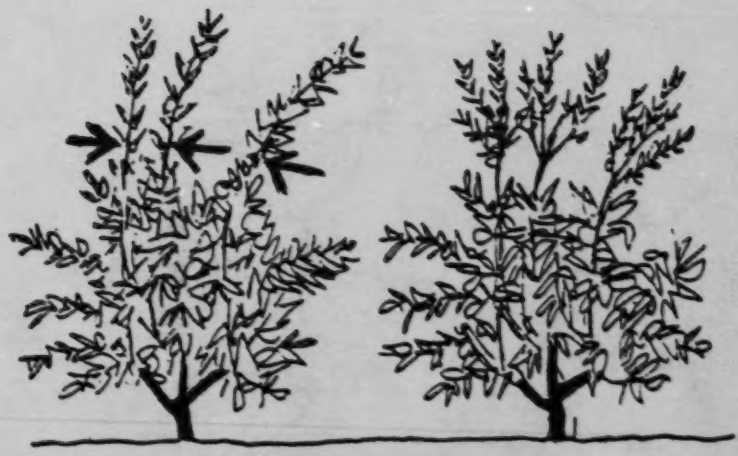
Just above the bud.

Above a healthy side branch.

Leave only main branch.

Cut to base or ground; file off stubs.

But never prune so that long stubs rem



If you cut at points shown by large arrows, stubs may sprout at cut.

Instead, cut off runaways at base.

UNIT TEST:

1. Match:

_____a. Thinned out	(1) A tree that loses its leaves in the winter.
_____b. Headed back	(2) To interweave and plait branches of trees together to form a hedge or arbor.
_____c. Pleach	(3) A tree from which the top has been sheared so that it puts out a dense head of slender shoots.
_____d. Deciduous tree	(4) The end of a branch, shoot, cane, or twig removed.
_____e. Pollard	(5) The entire branch, shoot, cane, or wig removed.
_____f. Coniferous tree	(6) A tree that is evergreen.

2. List two general reasons for pruning ornamental trees.

3. Select from the following statements those that are rules for removing dead, diseased, or injured branches.

_____a. Leave some stubs.
_____b. Keep the pruning tools sterilized at all times.
_____c. Do not seal cuts.
_____d. Cut back frostbitten wood a little at a time.

4. a. List three general rules for keeping deciduous trees within dimensions of an area.
   b. List four general rules for keeping coniferous trees within dimensions of an area.

5. State three effects of pruning ornamental trees.

6. Select as True or False the following statements pertaining to pruning to shape a tree.

_____a. To permit traffic to circulate under the tree.
_____b. To make various designs, such as arbor by pleaching.
_____c. Topiary trees grow naturally.
_____d. "Weeping trees" that reach the ground must be trimmed in order for the tree to have aeration for the trunk and branches to grow strong.

7. Select from the following statements those that describe a procedure for pruning to strengthen trunk and branches.

_____a. If the tree is fast-growing and produces brittle growth, it should be cut back hard after it has a sturdy root system.
_____b. A fast-growing brittle tree will form new buds if they are cut back to a bud.
_____c. Cut back fast-growing brittle trees between August and October.

8. State two specific uses for pruning for basic landscaping purposes.

ANSWERS TO UNIT TEST:

1. a. (5)
   b. (4)
   c. (2)
   d. (1)
   e. (3)
   f. (6)

2. a. To remove dead, diseased, or injured branches.
   b. To keep the trees within the dimensions of the area.

3. b,d

4. a. Any of the following three will be acceptable:
   *Pinch out tips of branches at low level.
   *Remove lower branches in the third or forth year or when the head of the tree is large enough to take over growth.
   *Prune in late winter when the branches are bare.
   *Some trees can also be pinched back, cleaned up or sheared in the summer or fall.
   b. Any of the following four will be acceptable:
   *Pinched, headed back, and thinned out depending on type and variety.
   *Junipers must be pruned regularly to keep them in bounds.
   *Prune generally before Christmas.
   *Tree forms need less pruning than lower growing forms.
   *Some evergreen need heavy shearing in the spring, such as arbivate.

5. a. Pruning to shape.
   b. Pruning to strengthen trunk and branches.
   c. Pruning for specific landscape use.

6. a. (T)
   b. (T)
   c. (F)
   d. (T)

7. a,b,d

8. a. To conform with the area available.
   b. To use the area to best advantage.

Deciduous and Evergreen Shrub Pruning

I. Terms and Definitions.

A. Pruning - Removal of unwanted growth.
B. Rejuvenate - To make as if young again.

II. Some Reasons for Removing Unwanted Growth from Deciduous Shrubs.

A. To produce more or better bloom and/or fruit.
B. To develop or maintain a desired shape or size.
C. To rejuvenate, by taking out older stems to encourage vigorous young ones to take their places.
D. To repair injuries.
E. To remove parts that are diseased or seriously injured by insects, such as fireblight, stem borers, scale insects, etc.
F. To establish a balance between root and branch systems after transplanting, particularly with shrubs moved with bare roots.
G. To remove dead wood or that which is winter-killed.

III. Facts About Proper Pruning Tools for Pruning Shrubs (See section on Introduction to Pruning).

A. Tools should be of good steel and always kept sharp.
B. Hand pruning shears come in sizes 7 to 9 inches long (the heavier type is preferred because its cutting blades are not so easily strained).
C. Pruning saws 12 to 14 inches long are large enough for most shrubs.
D. Loping shears with handles from 20 to 36 inches are used to cut stems from 3/4 to 1 1/2 inches in diameter where saws cannot be used.
E. A heavy pruning knife is usable for many purposes, especially for smooting surfaces cut with a saw.

NOTE: Do not use hedge shears for pruning shrubs.

IV. Seasons for Pruning Deciduous Shrubs.

A. In the winter when they are dormant: i.e., before growth begins in the spring.
B. Immediately after flowering (spring or early summer).

V. Some Deciduous Shrubs to be Pruned Every Year.

A. Prune to near the base of previous year's growth:

1. Butterfly-bush
2. Bluebeard
3. Eschscholtzia
4. Hills-of-Snow Hydrangea
5. Indigo
6. False-spirea
7. Tamarisk
8. Chaste-tree (vitex)

B. Prune by thinning out and heading back:

1. Beauty-berry
2. Heather (may be sheared)
3. Shrub Althea (all shoots should be cut at varying heights).

4. Peegee Hydrangea
5. Spireas (sometimes can be cut to the ground).

VI. Some Deciduous Shrubs to be Pruned Immediately After Flowering.

A. Fountain Butterfly-bush
B. Deutzia
C. Forsythia
D. Winter jasmine
E. Mock-orange
F. Spirea (all spireas that are spring flowering)
G. Lilac
H. Weigela

VII. How to Prune Deciduous Shrubs Immediately After Flowering.

A. Cut away the branches that have flowered.
B. Leave only the vigorous young shoots.
C. Older shoots (remaining from the previous year) should be cut out at ground level.
D. If pruning cannot be done at this time, an alternate time is in the winter, but remove only the old stems at their base.

VIII. How to Prune Deciduous Shrubs With Ornamental Fruits (Used for Autumn Fruits rather than Spring flowers).

A. Occasionally in the dormant season, the shrubs can be lightly thinned out.
B. Cut out old or weak stems.
C. Remove stems that are rubbing together.
D. No systematic shoot or branch pruning.
E. Prune every several years.
F. Prune enough to keep them neat but not formal in appearance.

IX. Some Deciduous Shrubs Grown for their Ornamental Fruits.

A. Barberry
B. Smoke-tree
C. Flowering Quince
D. Cotoneaster
E. Euonymus
F. Cornelian Cherry

X. How to Prune Deciduous Shrubs After Transplanting (planted bare rooted).

A. After planting, remove about 1/3 of the total growth.
B. For shrubs that sprout from the base (spireas, mock-orange), one or two older stems may be cut out at the base, and the remainder shorten about 1/3.
C. Shrubs with permanent stems (smoke-tree, Cornelian cherry) may have some of the weakest growth thinned out and the stronger branches shortened.

NOTE: Shrubs with the roots in a ball of soil wrapped in burlap usually require little if any pruning at the time they are planted.

XI. Facts About Pruning of Broad-Leaved Evergreens.

A. If not cared for, may become so poorly shaped as to be unsuitable as ornamentals.
B. Most broad leaved evergreens can tolerate considerable shade but will become spindly when grown in heavy shade.
C. Select the best site that will develop the best qualities for which it is being grown - foliage, flowers, or fruit.
D. Spindling or developing of leggy plants growing in heavy shade are best remedied by proper selection of site rather than relying on the temporary correction afforded by pruning. Either move the plant or thin the dense shade by thinning out.
E. By pinching out soft tips of shoots of broad-leaved evergreens, it is possible to develop compact plants with branches near the ground level.
F. By removing foliage, fruit, and flowers for decorative p poses inside the home, selective and continual pruning is carried out.

XII. Facts About Sanitary Pruning of Broad-Leaved Evergreens.

A. Most should be pruned just before new growth starts in the spring.
B. Some shrubs, such as mahonias or camellia japonica (which have fully developed flower buds going into winter), should be pruned immediately after flowering.
C. Pruning of azaleas is limited to "pinching out" the tips of shoots on young plants and the "heading back," or removal, of older branches on "leggy" specimens. Do this several times a year.
D. Barberries, cotoneasters, and pyracantha (grown for fruiting effect) need very little pruning except to induce compactness in their young stage or to maintain them in scale with their surroundings.

XIV. Facts About Pruning of Narrow-Leaved Evergreens.

A. If they are left to grow without pruning, in a few years they become ragged, openbranched, overgrown, and unnattractive.
B. Pfitzer juniper is a vigorus grower and, unless pruned, it may soon become too wide for its allotted space.
C. Upright junipers and arborvitaes frequently become too tall and open-branched if left unpruned.
D. Arborvitaes, yews, and junipers usually need occasional pruning to preserve their shape and size.

1. Can be pruned back at the ends of their branches.
2. New buds form and grow quickly, and at so many places that the location of existing dormant buds may be disregarded.
3. Prune when the new foliage is soft.

E. Tall growing evergreens, such as the American arborvitae, red cedar and their varieties, may be pruned with a sharp knife in late spring or early summer.

1. Sweeping motions with the blade of the knife up along

the edge of the tree or shrub can remove the ends of the new growth that extend beyond the normal outline. DO NOT OVERDO AND GIVE THE PLANT A SHEARED LOOK.

2. New foliage and branching is stimulated and the shrub or tree becomes dense and well filled out.

XV. Pruning Evergreens Every Year or Two Will Prevent the Necessity of a Major Operation At Any One Time.

UNIT TEST:

1. Define the following terms:
   a. Pruning
   b. Rejuvenate

2. List five reasons for removing unwanted growth from deciduous shrubs.

3. State four facts about tools for pruning shrubs.

4. Name two seasons for pruning deciduous shrubs.

5. a. List three deciduous shrubs that are pruned every year near to their base.
   b. List three deciduous shrubs that are pruned by thinning out and heading back each year.

6. List five deciduous shrubs to be pruned immediately after flowering.

7. Select as True or False the following statements about how to prune deciduous shrubs immediately after flowering.
   _____a. Cut away the branches that have flowered.
   _____b. Leave only the old shoots.
   _____c. Cut the tips off the old shoots.
   _____d. This pruning can be done in the winter as an alternate time.

8. Choose from the following statements those that apply to how to prune deciduous shrubs with ornamental fruits.
   _____a. Occasionally in the dormant season, the shrubs can be lightly thinned out.
   _____b. Do not remove the old or weak stems.
   _____c. Remove the stems that are rubbing together.
   _____d. No systematic shoot or branch pruning.
   _____e. Prune three times a year.
   _____f. Prune enough to keep them neat but not formal in appearance.

9. List three deciduous shrubs grown for their ornamental fruits.

10. State two facts about how to prune deciduous shrubs after transplanting.

11. State three facts about pruning of broad-leaved evergreens.

12. Choose from the following statement those that are true of sanitary pruning of broad-leaved evergreens.

_____a. Dead or weak wood should be removed for appearance sake alone.

_____b. Dead or weak wood should be removed because of its effect on the future health of the plant.

_____c. Plants cluttered with weak and dying wood often become heavily infested with insects.

_____d. Plants cluttered with weak and dying wood often produce a large mass of flowers.

13. State three facts about various times to prune broad-leaved evergreens.

14. Name three facts about pruning narrow-leaved evergreens.

15. Select the proper word for the blank in the following statement:

"Pruning evergreens every year or two will _____ the necessity of a major operation at any one time."

ANSWERS TO UNIT TEST:

1. a. Removal of unwanted growth.
   b. To make as if young again.

2. List any five of the following statements. Wording to be approved by the instructor.

   * To produce more or better bloom and/or fruit.
   * To develop or maintain a desired shape or size.
   * To rejuvenate, by taking out older stems to encourage vigorous young ones to take their places.
   * To repair injuries.
   * To remove parts that are diseased or seriously injured by insects, such as fireblight, stem borers, scale insects, etc.
   * To establish a balance between root and branch systems after transplanting, particularly with shrubs moved with bare roots.
   * To remove dead wood or that which is winter-killed.

3. List any four of the following statements. Wording to be approved by the instructor.

   * Tools should be of good steel and always kept sharp.
   * Hand pruning shears come in sizes 7 to 9 inches long, with the heavier types to be preferred as their cutting blades are not so easily strained.
   * Pruning saws 12 to 14 inches long are large enough for most shrubs.
   * Lopping shears with handles from 20 to 36 inches are used to cut stems from 3/4 to 1 1/2 inches diameter where saws cannot be used.
   * A heavy pruning knife is usable for many purposes, especially for smoothing surface cuts with a saw.

4. a. In the winter when they are dormant.
   b. Spring or early summer.

5. a. List any three of the following:

   * Butterfly-bush
   * Bluebeard
   * Eschscholtzia
   * Hills-of-Snow Hydrangea
   * Indigo
   * False-spirea
   * Tamarisk
   * Chaste-tree (vitex)

   b. List any three of the following:

   * Beauty-berry
   * Heather
   * Shrub Althea
   * Peegee Hydrangea
   * Spireas

6. List any five of the following:

   * Fountain Butterfly-bush
   * Deutzia
   * Forsythia
   * Winter jasmine
   * Mock-orange
   * Spirea
   * Lilac
   * Weigela

7. a. (T)
   b. (F)
   c. (F)
   d. (T)

8. a,c,d,f

9. List any three of the following:

   * Barberry
   * Smoke-tree
   * Flowering quince
   * Cotoneaster
   * Euonymus
   * Cornelian cherry

10. List any two of the following statements. Wording to be approved by the instructor.

    * After planting, remove about 1/3 of the total growth.
    * For shrubs that spout from the base (spireas, mock-orange), one or two older stems may be cut out at the base, and the remainder shortened about 1/3.
    * Shrubs with permanent stems (smoke-tree, Cornelian cherry) may have some of the weakest growth thinned out and the branches shortened.

11. List any three of the following statements. Wording to be approved by the instructor.

    * If not cared for, may become so poorly shaped as to be unsuitable as ornamentals.
    * Most broad-leaved evergreens can tolerate considerable shade but will become spindly when grown in heavy shade.
    * Select the best site that will develop the best qualities for which it is being grown - foliage, flowers, or fruits.
    * Spindling or leggy plants growing in heavy shade is best met by proper selection of site rather than relying on the temporary correction afforded by pruning. Either move the plant or thin the dense shade by thinning out.
    * By pinching out soft tips of shoots of broad-leaved evergreens, it is possible to develop compact plants with branches near the ground level.
    * By removing foliage, fruit, and flowers for decorative purposes inside the home, selective and continually pruning is carried out.

12. b,c

13. List any three of the following statements. Wording to be approved by the instructor.

    * Most should be pruned just before new growth starts in the

spring.

* Some shrubs, such as mahonias or camellia japonica (which have fully developed flower buds going into winter), should be pruned immediately after flowering.
* Pruning of azaleas is limited to "pinching out" the tips of shoots on young plants and the "heading back," or removal, of older branches on "leggy" specimens. Do this several times a year.
* Barberries, cotoneasters, and pyracantha (grown for fruiting effect) need very little pruning except to induce compactness in their young stage or to maintain them in scale with their surroundings.

14. List any three of the following statements. Wording to be approved by the instructor.

* If they are left to grow without pruning, in a few years they become ragged, open-branched, overgrown and unattractive.
* Pfitzer juniper is a vigorus grower and, unless pruned, it may soon become too wide for its alloted space.
* Upright junipers and arborvitaes frequently become too tall and open-branched if left unpruned.
* Arborvitae, yews, and junipers usually need occasional pruning to preserve their shape and size.
* Tall growing evergreens, such as the American arborvitae, red cedar and their varieties, may be pruned with a sharp knife in late spring or early summer.

15. Prevent

Special Pupose Pruning and Training

I. Terms and Definitions.

A. Pollard - A tree from which the top is sheared so that it puts out a dense head of slender shoots.

B. Pleach - To interweave and plait branches of trees together to form a hedge or arbor.

C. Shearing - Using hedge shears or grass shears to clip leaves, stems, and branches on one plant at one time.

D. Espalier - Describing a tree or shrub trained to grow flat - against a wall or along a fence, wire, or trellis.

E. Topiary - Describing a tree or shrub sheared to geometric shapes such as pyramids, spheres, and cones, or to bird and animal shapes.

F. Hedge - A row of one kind of plant.

G. Pergola - An arbor or trelliswork of a structural nature, covered with vegetation.

II. Some Facts About the Artistry of Pruning.

A. Woody plants have natural forms which vary tremendously, one kind from another.

B. Among trees alone, trunk character may vary from a tall, straight pole bearing a cluster of branches near the top to a short solid trunk giving rise to many varied, in length and size, of contorted shaped branches.

C. Before selecting plants, some knowledge of the mature form of a tree, shrub or vine (whether evergreen or deciduous) is necessary in order to place a plant with suitable characteristics in a particular place.

D. Sometimes it is desirable to change the shape of a plant to a degree or to simplify its form through pruning.

E. Some of these forms are:

1. Espalier.
2. Topiary.
3. Pleaching.
4. Pollard.
5. Hedges - inforaml and formal.

III. Facts About Espalier Trees and Shrubs.

A. Almost any tree or shrub that is not too rigidly upright or formal in growth can be espaliered.

B. Espaliering is an exacting but rewarding art.

C. Fruit trees make good subjects because espaliering exposes a maximum of branch surface to the sun, stimulating heavier flower and fruit production.

D. In cool summer areas give an espalier tree or shrub as much sun as possible by planting against a south wall or

fence.

E. Where summer temperatures hit the 90's for a length of time, reflected heat is likely to damage the plant or sunburn the fruit; so make an espalier on a free-standing trellis with an eastern exposure.

IV. Method of Pruning and Training An Espalier Fruit Tree (See Transparency Master No. 1).

A. Select a young tree, grafted on dwarfing root stock, which has a pair of main branches a foot or so from the ground.

B. To form a double U shaped espalier, first cut off small branches and shorten center leader to force new side shoots.

C. Build lattice to the full width of mature tree.

D. Bend branches carefully and tie in position to start forming first U.

E. Continually remove growing points that would take growth in the direction not wanted, and allow the rest of the growing points to have their own way.

F. After a few years of growth, the double U is pruned from spurs from the central leader.

V. Facts About Making Topiary Trees and Shrubs (See Transparency Master No. 3).

A. A way of pruning trees and shrubs that goes back in history to the Roman Empire.

B. Used extensively in the 18th century in Europe.

C. Used very little today.

D. Topiary shrubs are usually yew, boxwood, or privet.

E. Easiest shapes to manage are spirals, balls, and cubes.

F. Takes many years to create these forms.

VI. Facts About Pleaching (See Transparency Master No. 2).

A. Any tree can be pleached that has branches and shoots tough and supple enough to be bent and interwoven without breaking.

B. To make an arbor of pleached trees, build a sturdy framework of wood, angle iron, or galvanized pipe on which to train the trees.

C. It will take as many vertical supports as trees, as well as sufficient material to build a pergola-type trellis between the tops of the uprights.

VII. Facts About Pollarding (See Transparency Master No. 2).

A. Tops of trees are sheared off so that it puts out a dense head of slender shoots.

B. Because of the severe pruning involved, a pollard is often unsightly with large ugly knobs.

C. Unless a tree has to be kept a certain size, there is little reason to pollard.

IX. Facts About Hedges - Informal

A. An informal hedge can be simply a row of one kind of plant.

B. It grows naturally.

C. Pruning consists of occasional heading back, thinning out, or pinching to keep the plant bushy and of desired shape.

D. Diseased, broken, or injured branches are removed in a natural manner.

X. Facts About Hedges - Formal

A. A formal hedge should be sheared regularly during its entire life.

B. Proper training begins at planting time.

C. Never allow a formal hedge to reach the size you want before shearing it.

D. At all stages of growth hedges should be maintained so that their sides are either vertical or sloping in some from bottom to top (allows sun to reach the leaves at the bottom of hedge).

XI. Method of Pruning and Training Formal Hedges.

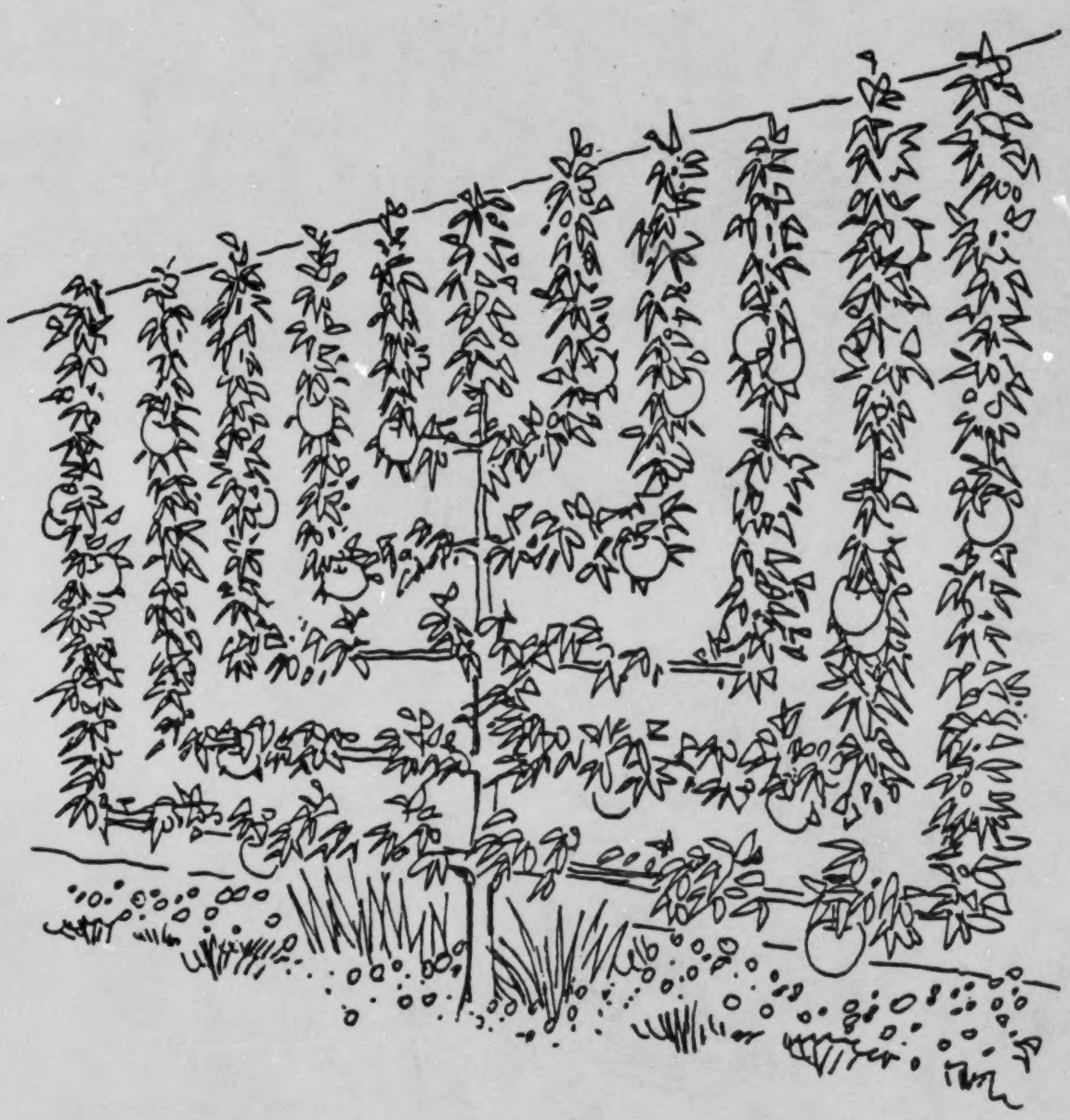
A. If the young plants (at planting time) are already nicely branched, do not cut them back severly.

B. Head back the tops and sides as necessary to induce branching.

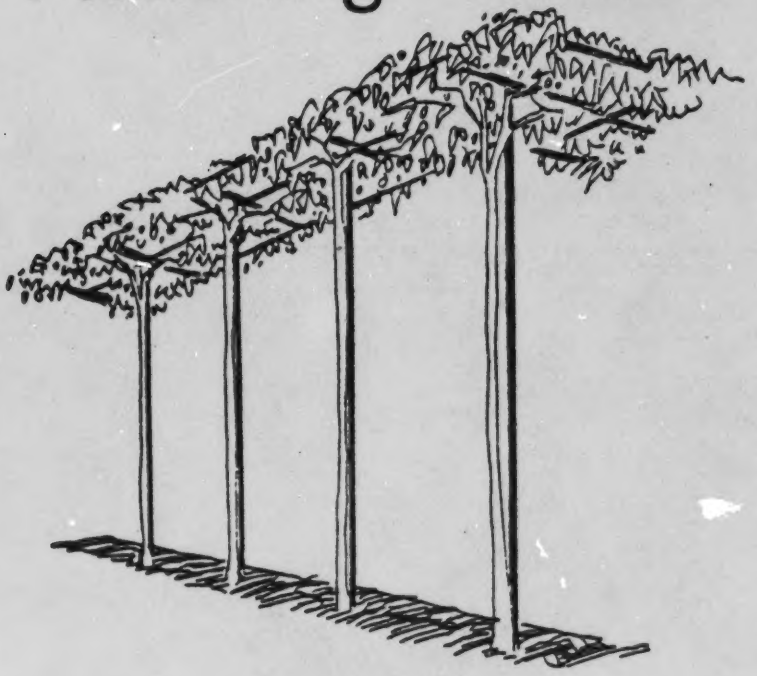
C. Continue this procedure over several seasons until the desired shape and size is reached.

D. Shear the hedge in early spring so that the plants will spread widely and develop a dense and low-branched framework.

Training an Espalier Fruit Tree



Pleaching—Pollarding



Pleaching

Pollarding

Topiary Designs

UNIT TEST:

1. Match:

_____a.	Hedge	(1)	Describing a tree or shrub sheared to geometric shapes.
_____b.	Pergola	(2)	Using hedge shears or grass shears to clip leaves, stems, and branches on one plant at one time.
_____c.	Pollard	(3)	To interweave and plait branches of trees together to form a hedge or arbor.
_____d.	Shearing	(4)	Describing a tree from which the top is sheared so that it puts out a dense head of slender shoots.
_____e.	Espalier	(5)	A row of one kind of plant.
_____f.	Topiary	(6)	An arbor of trelliswork of a structural nature, covered with vegetation.
_____g.	Pleach	(7)	Describing a tree or shrub trained to grow flat - against a wall or along a fence, wire, or trellis.

2. List three factors about the artistry of pruning.

3. State three facts about making espalier trees or shrubs.

4. Indicate with numbers the proper sequence of steps in pruning and training to make an espalier fruit tree.

_____a. Build lattice to the full width of mature tree.

_____b. Bend branches carefully and tie in position to start forming first U.

_____c. Select a young tree, grafted on dwarfing root stock, which has a pair of main branches a foot or so from the ground.

_____d. To form a double U shaped espalier, first cut off small branches and shorten center leader to force new side shoots.

_____e. Continually remove growing points that would take growth in the direction not wanted, and allow the rest of the growing points to have their own way.

_____f. After a few years of growth, the double U is pruned from the central leader.

5. State three facts about making a topiary tree or shrub.

6. Identify as True or False the following statements about pleaching.

_____a. Any tree can be pleached that has branches and shoots tough and supple enough.

_____b. No home-made framework is necessary.

_____c. Each tree needs a vertical support.

7. Indicate with numbers the proper sequence of steps in pruning an arbor of pleached trees.

_____a. Remove all upright growth.

_____b. Leave no stubs.

_____c. Where branches cross, intertwine them; they'll form natural grafts.

_____d. Every year, bend, tie, or weave the new growth to keep the plane of canopy level.

_____e. Plant and tie a tree to each vertical support (8 to 16 feet high).

_____f. Remove side branches that develop along the trunk.

_____g. Lead all side branches toward those of the neighboring trees, bending them dowm to the framework and tying as necessary.

_____h. Weave them under and over the wires or with other branches.

_____i. When foliage is abundant and reaches well into the overhead framework, training may begin.

8. List two facts about pollarding.

9. Select form the following statements those that pertain to informal hedges.

_____a. A row of one kind of plant.

_____b. It grows naturally.

_____c. No pruning or pinching is ever necessary.

_____d. Diseased, broken, or injured branches are moved in a natural manner.

10. List three facts about formal hedges.

11. Select from the following statements those that pertain to pruning and training of formal hedges.

_____a. If young plants are already nicely branched, do not cut back severely.

_____b. Do not induce branching by heading back the tops or sides.

_____c. Continue shearing over several seasons until the desired shape and size is reached.

_____d. Shear the hedge late in the summer so that the plants will spread widely and develop a dense and low-branched framework.

ANSWERS TO UNIT TEST:

1. a. (5)
   b. (6)
   c. (4)
   d. (2)
   e. (7)
   f. (1)
   g. (3)

2. List any three of the following statements. Wording to be approved by the instructor.

   * Woody plants have natural forms which vary tremendously, one kind from another.
   * Among trees alone, trunk character may vary from a tall, straight pole bearing a cluster of branches near the top to a short solid trunk giving rise to many varied, in length size, contorted shaped branches.
   * Before selecting plants some knowledge of the mature form of a tree, shrub or vine, whether evergreen or deciduous, is necessary in order to place a plant with suitable characteristics in a particular place.
   * Sometimes it is desirable to change the shape of a plant to a degree or to simplify its form through pruning.
   * Some of these forms are: espalier, topiary, pollarding, pleaching, and hedges.

3. List any three of the following statements. Wording to be approved by the instructor.

   * Almost any tree or shrub that is not too rigidly upright or formal in growth can be espaliered.
   * Espaliering is an exacting but rewarding art.
   * Fruit trees make good subjects because espaliering exposes a maximum of branch surface to the sun, stimulating heavier flower and fruit production.
   * In cool summer areas, give espalier as much sun as possible by planting agaist a south wall or fence.
   * Where summer temperatures hit the 90.s for a length of time, reflected heat is likely to damage the plant or sunburn the fruit; so espalier on free-standing trellis with an eastern exposure.

4. a. 3
   b. 4
   c. 1
   d. 2
   e. 5
   f. 6

5. List any three of the following statements. Wording to be approved by the instructor.

   * A way of pruning trees and shrubs that goes back in history to the Roman Empire.
   * Used extensively in the 18th century in Europe.
   * Used very little today.
   * When topiary is used, yew, boxwood, or privet is the shrub used.

* Easiest shapes to manage are spirals, balls, and cubes.
* Takes many years to create these forms.

6. a. (T)
   b. (F)
   c. (T)

7. a. 4
   b. 5
   c. 8
   d. 9
   e. 1
   f. 2
   g. 6
   h. 7
   i. 3

8. List any two of the following statements. Wording to be approved by the instructor.
   * Tops of trees are sheared off so that it puts out a dense head of slender shoots.
   * A very unsightly tree because of the severe pruning causes large, ugly knobs.
   * Unless a tree has to be kept a certain size, there is little reason to pollard.

9. a,b,d

10. List any three of the following statements. Wording to be approved by the instructor.
    * A formal hedge should be sheared regularly their entire life.
    * Proper training begins at planting time.
    * Never allow a formal hedge to reach the size you want before shearing it.
    * At all stages of growth, hedges should be maintained so that their sides are either vertical or sloping in some from bottom to top (allows sun to reach the leaves at the bottom of hedge).

11. a,c

LIVESTOCK SKILLS

Instructor's Guide:

1. This unit is intended to provide background information in common livestock skills. For effective instruction, the skills must be performed on live animals.

2. Transparency masters are found at the end of each lesson.

3. Students should be provided with unit objectives and handouts.

4. Student performance evaluation must be established prior to instruction and clarified to students so that instructional outcomes will be met.

5. Materials for this unit have been selected from Texas A & M Curriculum Materials.

Objectives:

Upon completion of this unit, the student will be able to:

1. Halter a calf.
2. Halter a foal.
3. Lead horses and cows.
4. Practice tail restraint on cows.
5. Use a nose lead on cattle.
6. Restrain a cow from kicking.
7. Cast a cow by the rope method.
8. Restrain swine by hand, hog holder, and rope noose methods.
9. Properly catch and hold sheep.
10. Hold a sheep for fleece inspection.
11. Hold a lamb for castration and docking.
12. Twitch a horse.
13. Drive and load animals into a truck.
14. Explain advantages of common dehorning methods.
15. Dehorn calves.
16. Castrate calves, lambs, and pigs.
17. Dock sheep.
18. Brand cattle.
19. Ear notch animals.
20. Ear tag animals.
21. Tattoo animals.
22. Define vaccine bacteriums and serums.
23. Describe basic injection procedures and kinds of injections.
24. Do a subcutaneous injection.
25. Do an intramuscular injection.

Student Activities:

1. Read objectives.
2. Study student material handouts.
3. Practice livestock skills by working with local farmers on field trips, individual assignments, or on home farm.
4. Take unit exam on materials covered in class.

Teaching Aids:

1. Objectives for unit.
2. Transparency masters.
3. Common livestock tools for demonstrations.

   Rope and leather halters

   Ropes

   Dehorners - Barnes, Clippers, saw

   Castration equipment - elastrators, burdizzo, scalpel

   Restraint devices - kickers, twitches, etc.

   Branding, tagging, ear notching equipment

   Syringes, needles, and other injection equipment

   Disinfectants

References and Resources:

Ensminger, M.E. The Stockman's Handbook, Fifth Edition, the Interstate Printers and Publishers, Inc., Danville, Illinois. 1979.

Local Veterinarian

County Extension Agent

Terms and Definitions:

Atrophy - Following the use of the elastrator for castration the scrotum and testicles will decrease in size or finally wither away due to the blood supply being cut off.

Castrate - Remove the testicles of a male animal.

Scurs - Small, loosely attached horns that sometimes appear on polled animals.

Stag - A male animal that was castrated after it reached sexual maturity (horses included).

Steer - A male bovine animal that was castrated before reaching sexual maturity.

Wether - A male lamb castrated under one year of age.

Yearlings - Cattle between one and two years of age.

LIVESTOCK SKILLS

Topic 1: Handling and Restraint of Animals

I. Haltering Livestock

The two classes of livestock that are usually haltered and trained to lead are cattle and horses. When training animals in either class to lead, the best time to train them is while they are young (three to four months of age).

There are several different kinds of halters and hackamores, usually made from rope, that may be used to train cattle and horses to lead.

A. Haltering the Calf

At the beginning of the training period, the calf should be haltered and tied for short intervals. Approximately two feet of rope should be allowed between the calf and the tie, which should be at the same level as the calf's head; and the calf should be tied to something substantial. Show calves are sometimes trained by leading them to and from their nurse cow or mothers. After the calf has been led short distances, it should be taken for longer walks. Assistance may be needed if the calf balks. Pulling the calf to one side and then to the other sometimes causes it to resume walking. Another method used to get a calf to walk is to make a large, non-slipping loop and place the loop over the calf's back and above his hocks. Applying the same amount of pressure to the non-slipping loop rope as is applied to the lead rope may cause the calf to walk.

B. Haltering the Colt

Six to eight half-hour lessons, depending upon a colt's disposition, are usually required to train a colt to lead; older horses will require more time. Training colts to lead while young makes them easier to handle, causes less injuries, and makes better working horses out of them.

When the trainer begins to train the young colt to lead, they should pen the colt by itself and away from other horses so that they can retain its attention. Using the mare, the trainer should crowd the colt into a corner to catch it. The colt should be approached as quietly as possible; the trainer should catch the colt by placing one arm around the front and under its neck; the other arm should be placed around the rear legs of the colt and below its tail head. The trainer may need to secure assistance

the first few times the colt is caught to prevent injury to it. After the colt is caught, the trainer should pet and brush it to relieve its fears. To prevent injury to the colt, the trainer should tie the colt above the level of its head. Some trainers use an innertube which has been tied to something substantial to train the colt to stand. The innertube expands and contracts as the colt applies and releases pressure on the halter rope. Since the care of horses' feet is important, the trainer should include the picking up of the colt's feet as a part of its training. Great patience and carefulness are required to train the colt properly. One should never attempt to handle a young horse until they are sure they can control their own temper and keep absolutely calm and quiet while handling it. When training the colt to lead, the trainer may have to pull the colt gently from one side then to the other side to get the colt to walk. As was mentioned in the paragraph on training a calf to lead, the trainer, after the colt has had two or three leading lessons and has been gentled some, may use a non-slip loop to make the colt walk. The non-slip loop is slipped over the colt's hindquarters.

II. Restraint of Animals

Since it is necessary to apply restraint to most animals at times, several methods of restraint that can be used on different classes of animals will be discussed.

A. Restraint of Cattle

Cattle must often be restrained in order to brand, dehorn, mark, castrate, fit for show, and for other reasons. The cattleman should use the most practical means of restraint when preparing to perform one of the above operations. Some of the factors that should be considered to determine the method of restraint to use are the age of the animal, kinds of equipment available, availability of labor, time needed to perform the operation, and personal preference.

Transparency No. 1

The tail restraint, nose lead, and the grasping of the nostrils with the hand are methods of restraint that divert the animal's attention from an area of pain to the pain caused by the restraint. It may be necessary to apply more than one method of restraint to control an animal.

1. Tail restraint may be used to divert the cow's attention by grasping the tail near its base and by applying pressure in an upward and forward manner as shown. The person applying tail restraint should stand to one side of the animal to avoid being kicked. Tail restraint may be used when giving udder injections or other treatments to a nervous cow.

2. The use of a nose lead is one of the easiest ways to restrain a cow. It permits the user to perform several jobs such as giving injections, for examining specific areas of the body or feet, and for performing numerous other animal care practices.

3. Grasping the nostrils firmly with the thumb and forefinger may be sufficient for restraining some cattle in the absence of a nose lead depending on the temperament and size of the animal.

Transparency No. 2

To keep a cow from kicking, the handler may use the following methods of restraint:

1. Hobbles--Milking hobbles as shown here are a restraint often used by dairy farmers at milking time. The two metal clasps fit over the hind legs just above the hock. The chain may be adjusted to draw the legs closer together for more security.

2. Squeeze restraint--Another method of restraint to keep a cow from kicking. A rope loop is formed around the cow's body in front of the udder as shown. When the rope end is pulled tight, it squeezes the cow and generally will cause it to stand still (assuming that its head is secured).

3. Front leg hobble--A rope with an eye in one end is looped around the pastern and the loose end is passed over the cow's withers where it can be held by someone from the opposite side. In this way, a front leg can be raised and held off the ground for examiniation or treatment.

4. Beam hook method--In applying this method to raise the rear leg, the cow's head should be pulled to the side opposite the rear leg which is to be examined. Then a piece of rope with an eye is looped around the cow's leg below the fetlock and the free end is passed upward through a ring or hook that is fastened to a beam above and somewhat behind the cow. After the rope is passed through the hook, the end is brought down around the same leg above the hock and a half hitch is formed. The rope end is then carried forward and wrapped around the stanchion or some other object to secure it. As the cow's foot is lifted off the ground, the slack may be taken up.

5. Trimming rack--This rack may be used for several purposes but it is basically designed for hoof trimming. The band or sling attached to a beam on each side supports the animal's weight, thus permitting the feet to be raised and secured to the timber or support at the side.

Transparency No. 3

The method of restraint used will be determined generally by the operation to be performed.

1. Burley method of casting and restraint--With the cow's head secured, a 40 foot piece of rope is placed over her back with the center at the withers. The ends are then passed under the fore legs and crossed with an end then being carried up each side of the cow's body and the two are crossed again over the back. Each rope end then passes downward between the rear legs. When the ends of the rope are pulled the animal will fall. The operator can control the direction of fall by pulling the casting ropes to force the animal to one side or the other. The rear legs can then be secured by placing a half hitch around the fetlock and then passing the free end over the hock, across the cannon bone, and back around the fetlock.

2. Rope method of casting--A loop is first placed around the animal's horns or neck and then two half hitches are made around the animal's body behind the shoulder and in front of the hip bone. When the rope is pulled and enough pressure is applied, the animal will fall and then can be secured by keeping pressure on the rope and by tying the feet.

3. Dehorning restraint--This method of restraint may be used to hold a cow's neck securely to a post or other object while dehorning.

B. Restraint of Swine

Transparency No. 4

Since swine cannot endure rough handling, especially in hot weather, and because of the thin, easily broken bones in their legs, the methods used to restrain hogs are very important. A good set of pens and portable panels are necessary to properly handle hogs. Some of the methods for restraining swine are shown here.

1. Commercial hog holder--One of the most effective methods of restraining hogs is the use of a snare or wire cable which is passed around the hog's snout. It should be placed around the upper jaw behind the tusks and then held securely.

2. Nose holder--A piece of rope looped around the upper jaw of the snout in the same manner as above may also be used to secure the hog.

3. Pig restraining trough--A "V" shaped trough as shown may be useful for holding and securing pigs.

4. Another effective method of restraining pigs for castration or vaccination when suitable equipment is not available is shown. With the animal on its back, the holder is kneeling or sitting across the front section of the animal's body and is holding the hind legs securely in each hand. This makes it very easy for the operator to perform his tasks.

C. Restraint of Sheep

Transparency No. 5

Most sheep are raised in large flocks, and sheep are restrained in order to be sheared, drenched, dipped, docked, castrated, and vaccinated. One of the most important factors to remember in handling sheep is not to catch and hold them by their wool; handling them in this manner bruises the skin.

1. Catching and holding sheep--The preferred way to catch a sheep by hand is to place an arm under the jaw and around the neck.

   When holding a sheep, stand on the animal's left side, placing the left hand under the jaw and the right arm around behind his thighs. The left arm will prevent the animal from moving forward while the right arm will stop backward movement.

   Don't attempt to hold a sheep by pulling on his head, horns, or wool.

2. Fleece inspection--The handler should press the sheep's head and neck against their left leg with their left arm. By holding the sheep in this manner, the handler is able to examine the wool on the animal's shoulder and side. The condition and density of the wool can be examined by laying the hands flat on the surface of the fleece and gently forcing it to part. The best wool grows on the side of the shoulder where this part is being made. The holder may need assistance in holding the sheep while examining the belly and britch wool.

3. Docking and castrating--Restraint to perform these two operations may be administered by holding the front and rear leg on either side in each hand while supporting the back against the body (if standing) or between the legs (when seated).

The sheep is held in the standing position for drenching. The handler usually stands astraddle the sheep and holds it by applying pressure with their legs against the sheep's body; they place their left hand under the sheep's chin to hold its head. The handler's right hand is used to drench the sheep.

The methods used to restrain goats are the same as those for sheep; however, many goats have horns which make them much easier to catch and hold.

D. Restraint of Horses

Because of their size, strength, and the ability of horses to inflict fatal injuries, the trainer must be able to restrain them. Horses are quick to detect nervousness or a lack of self-confidence on the part of the trainer, so the trainer must have a direct and confident approach. Horses are appreciative of kindness, and a piece of sugar or a little feed will move a horse quicker than a threat.

When determining the type of restraint to use, the trainer should consider the horse's temperament, and no more restraint should be used than is necessary to control the horse.

Transparency No. 6

Breeding hobbles are used to prevent the mare from kicking the stallion during breeding and to allow the veterinarian to examine or operate on the rectum or vagina. A harness such as you see here may be used or ropes may be used to form the restraining hobbles.

Twitches are one of the oldest methods used to restrain horses. The pain produced by applying pressure on the sensory nerves of the horse's lips diverts their attention from the operation or treatment to the pain produced by the twitch. The twitch may be the ideal type of restraint to use on some horses, while its application on other horses may cause them to become less tractable.

The principle of the yankee war bridle is the same as that of the twitch. Pressure on the rope causes pain, thus diverting the horse's attention.

The side stick is used to prevent the horse from reaching the posterior half of their body with their mouth; however, it allows the horse freedom of movement and does not prohibit the horse from eating at ground level.

The cradle is used to prevent the horse from turning their neck and prevents them from reaching their body or legs. Either the cradle must be removed or the feed raised to the height of the horse's mouth in order for the horse to eat.

The tail tie is useful as a restraint because most of a horse's weight can be supported by their tail; the tail is very useful in lifting hind legs of horses.

A newborn foal should not be restrained by catching hold of its body parts but should be held in the manner recommended in the transparency.

III. Driving, Herding, Loading, and Hauling Livestock

Many of the animals reaching our livestock market today are bruised; in fact, research indicates that one out of every ten hogs marketed is bruised. The average loss per injured hog is $5.00. One out of each fifteen head of cattle marketed is bruised; and in addition to the reduction of the value of the meat that is left, there is a loss of $10-12 in the value of the carcass. These losses can be greatly reduced by the following means:

A. Use canvas slappers instead of sticks, whips, canes, or clubs.

B. Eliminate loading hazards such as protruding nails, equipment in pens, and broken boards.

C. Maintain adequate loading facilities: docks, alleys, and chutes.

D. Bed trucks properly. In summer, bed truck with sand; the sand should be wet when hauling hogs. In winter, the truck should be bedded with straw when hauling sheep or hogs, and it should be bedded with sand when hauling cattle.

E. Load carefully. When loading livestock, the trucker should handle the animals slowly and easily. If possible, the animals should be given time to acquaint themselves with pens and chutes before the trucks arrive. According to research, animals prefer to walk up steps.

Partitions should be used to separate loaded animals and to prevent fighting and trampling. Partitions should also be used to segregate the different classes of animals, and they may be used to assist the trucker in loading the correct number of animals in a given area. Too few animals loaded in a given area cause them to be tossed around, and too many animals for a given area cause excessive shrinkage, bruises, and possibly death.

F. The Driver. A good driver will avoid sudden stops and be considerate to the animals being hauled. Fast starts and stops cause injury to animals.

IV. Determining the Number of Animals to Load

The factors listed below will assist the stockman in determining the number of animals to load on a given truck:

A. Amount of fill

B. Size, sex, and age of animals

C. Distance to market

D. Weather conditions

E. Conditions of vehicle

Transparency No. 7

The recommendations for the number of animals to load in a truck were secured from "Livestock Conservation, Inc.", Union Stock Yards, Chicago, Illinois.

LIVESTOCK RESTRAINTS

TAIL RESTRAINT

811

NOSE LEADS

GRASPING THE NOSTRILS

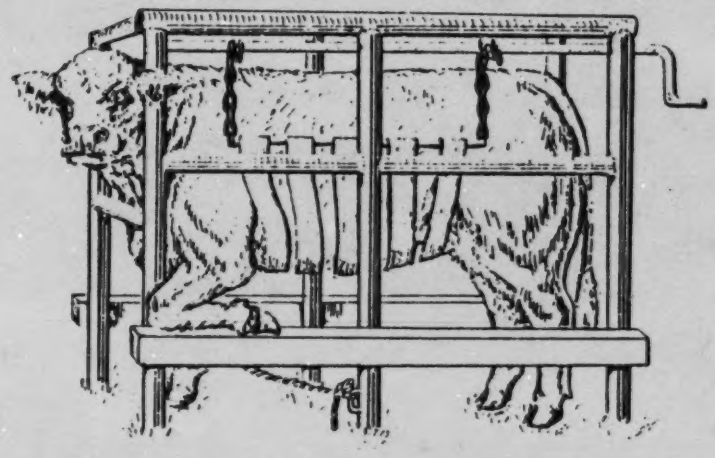
812

TH-1

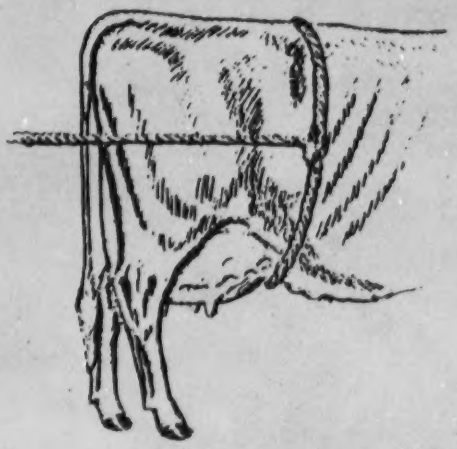
AgI-XIII-14

RESTRAINTS THAT PREVENT KICKING

HOBBLES



TRIMMING STOCK



SQUEEZE RESTRAINT

TM-2

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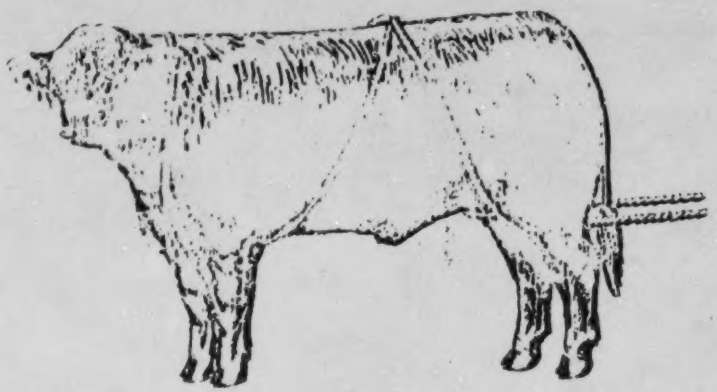
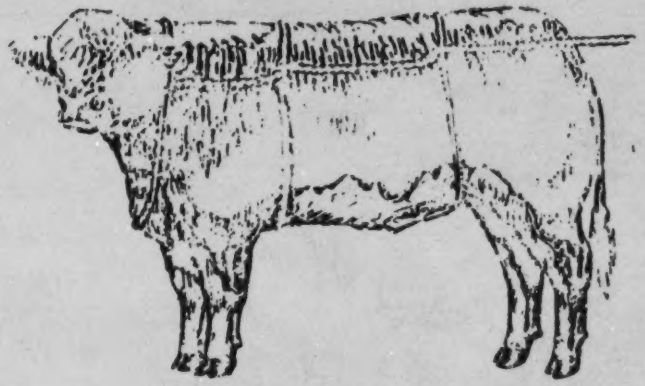
813

814

CASTING AND RESTRAINING METHODS



BURLEY METHOD OF CASTING AND RESTRAINT



ROPE METHOD OF CASTING

DEHORNING RESTRAINT

METHODS OF RESTRAINING SWINE

HAND RESTRAINT

COMMERCIAL HOG HOLDER

NOOSE

PIG RESTRAINING TROUGH

TM-4

AgII-XIII-17

RESTRAINING SHEEP

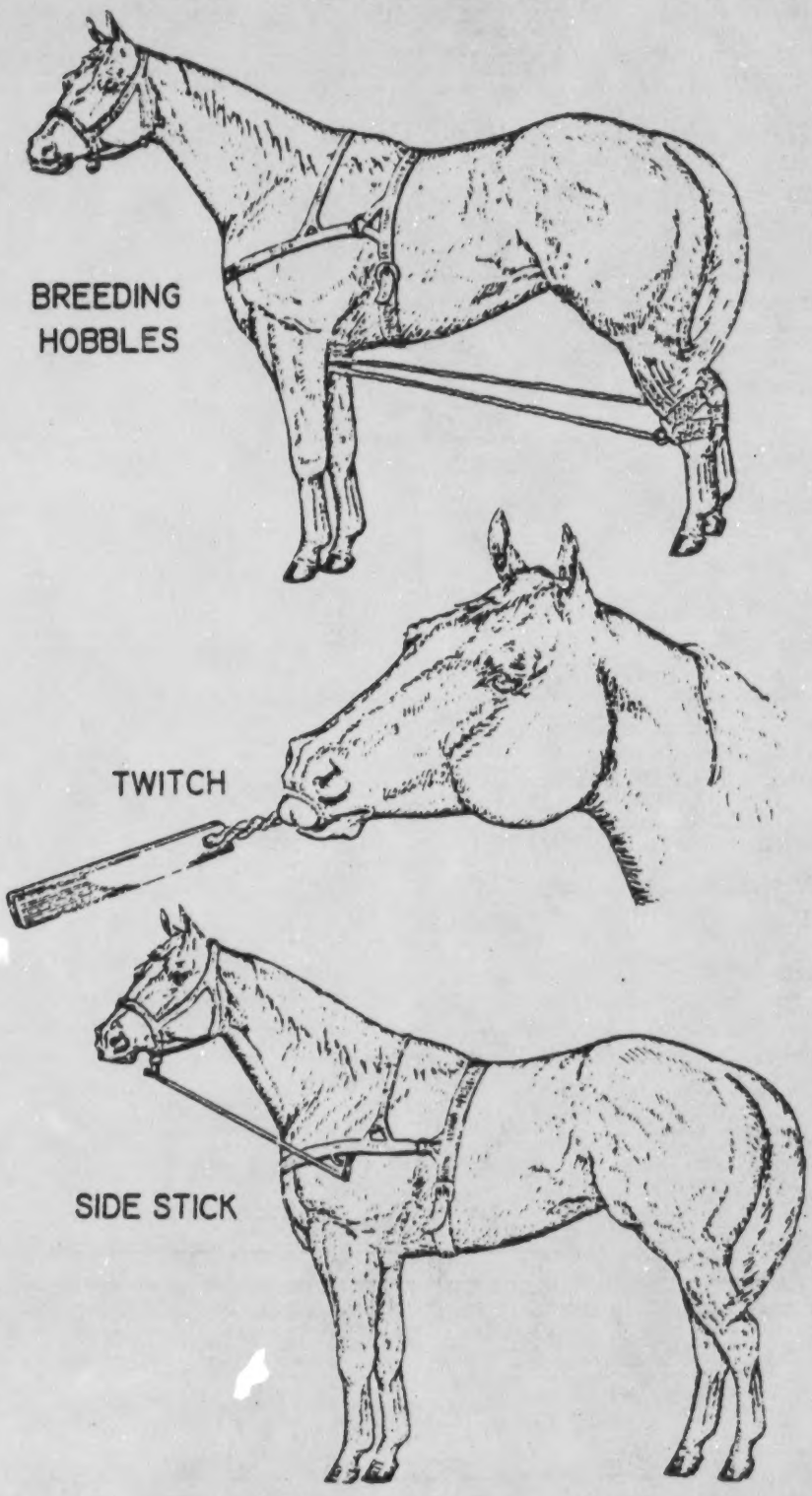
HOLDING

FLEECE INSPECTION

DOCKING AND CASTRATING

TM-5

RESTRAINTS OF HORSES



NUMBER OF CATTLE FOR SAFE LOADING IN A TRUCK

FLOOR LENGTH	AVERAGE WEIGHT OF CATTLE, LBS.					
	400	600	800	1000	1200	1400
(FT.)	(NO.)	(NO.)	(NO.)	(NO.)	(NO.)	(NO.)
8	8	7	5	4	4	3
12	13	10	8	7	6	5
18	20	16	13	11	9	8
24	27	22	17	15	13	11
30	34	27	22	19	16	14
42	48	39	31	28	22	20

NUMBER OF SHEEP PER DECK FOR SAFE LOADING IN A TRUCK

FLOOR LENGTH	AVERAGE WEIGHT OF SHEEP, LBS.			
	60	80	100	120
(FT.)	(NO.)	(NO.)	(NO.)	(NO.)
8	28	23	20	18
12	43	35	31	28
18	65	54	48	43
24	88	73	65	58
30	110	92	81	73
36	133	110	98	88

NUMBER OF HOGS & CALVES FOR SINGLE-DECK TRUCKS FOR SAFE LOADING

FLOOR LENGTH	AVERAGE WEIGHT OF ANIMALS, LBS.		
	150	200	300
(FT.)	(NO.)	(NO.)	(NO.)
8	21	18	13
15	39	33	24
24	62	52	38
30	77	66	47

NUMBER OF HOGS & CALVES FOR DOUBLE-DECK TRUCKS FOR SAFE LOADING (DIVIDE EQUALLY BETWEEN DECKS)

FLOOR LENGTH	AVERAGE WEIGHT OF ANIMALS, LBS.			
	150	200	250	350
(FT.)	(NO.)	(NO.)	(NO.)	(NO.)
10	41	36	30	23
15	62	54	45	34
20	83	72	61	46
28	116	101	86	64
32	133	115	97	73

TM-7

LIVESTOCK SKILLS

Topic 2: Castrating Livestock

*Terms: All terms underlined are in the "Glossary of Terms."

I. Castration as a Management Practice

Castration, or the removal of the testicles from the scrotum of the male is a common management practice often used by livestock breeders.

First, let's consider the function of these male reproductive organs. The testicles of male animals have two functions: the production of male germ cells and the production of male sex hormones. Testosterone, which is the male sex hormone, stimulates the development of the male reproductive organs, the growth processes, and affects the anatomy of certain parts of the male animal. One has noticed, undoubtedly, that male animals have heavier crests and necks, are heavier in the forequarters, and have more overall muscling than females or castrated animals.

Then, consider the effects of castrating the male and the reasons for performing this operation. The removal of the testicles eliminates the supply of testosterone which in effect alters the physical development of the male and supresses its sexual desires and behavior. This change in the physical development may improve the meat qualities of animals used for food consumption. Also, the behavior or temperament of the male may be changed to increase its suitability for handling and/or other purposes. More specific uses will be discussed in the information to follow.

A. Castration of Cattle

The early cattle producer had justification for castrating. They were unable to control large groups of mixed cattle because of a lack of fences and equipment, and the consumer demanded overfat beef. These conditions no longer exist.

Recent research conducted in several states and foreign countries proves the superiority of male beef animals in the production of beef. According to this research, male beef animals gain much faster than steers (up to one-half pound per day in some cases), weigh 5 to 10 percent more at weaning, produce leaner, more muscular meat, and produce meat that is acceptable to the consumer. Aniamls in the experiments were slaughtered at eighteen months of age or less. In preference tests, the consumer purchased lean meat whether it came from a bull, heifer, or steer carcass.

Even though there are weight gain advantages in feeding bulls and the quality of meat of the male beef animals is comparable to females and steers, the producer selling bulls on the market may receive less money per pound. However, they might make a greater net profit by feeding bulls because of faster gains and a shorter feeding period.

The two main reasons for discounting male beef animals were the U.S.D.A. grading standard requirements that the word "bull" be stamped on all known bull carcasses and the packers' hesitancy to accept male beef animals on their merits. Also, it is known that consumers are prejudiced against bull meat. However, under the new U.S.D.A. standards that went into effect January 1, 1973, beef from young bulls (to be identified as "bullocks") will be federally graded on the same standards as beef from steers. The revision in standards also included discontinuance of the quality grades for beef from older bulls since they are now being used almost exclusively in processed meat products.

Although livestock producers may continue to castrate some animals, chances are they will do less of it in the future.

Castration should generally be done when the calves are between one and three months of age.

Also in areas where the screw worm is a problem, it is best to castrate calves in the early spring or late fall to avoid infestation from flies. A good practice to follow when castration is done during the fly season is to apply a repellant to the wound.

The castrated bull calf is known as a steer.

Many FFA members and others who feed steers for the stock shows have recognized the superior muscle development of male animals. Because of this, some feeders fitting steers for show castrate as late as possible.

B. Castration of Swine

It is a common practice to castrate all male pigs that are not to be used for breeding purposes. They should be castrated at an early age while they are still nursing the sow. Pigs should be castrated far enough in advance of weaning to allow healing which usually takes 2 to 3 weeks. Generally this means that castration should be done within the first 4 weeks. Castration should not be done at the same time that the pigs are vaccinated.

If a male hog is allowed to reach sexual maturity (6 to 8 months of age), the cooked meat of this animal's carcass has an unpleasant odor and taste. For this reason, the producer needs to continue to castrate male pigs in order to produce quality pork.

The castrated male pig is known as a barrow.

C. Castration of Sheep

All male lambs that are not to be kept as breeding rams should be castrated when they are from 7 to 14 days old. Healthy, thrifty lambs may be castrated and docked at the same time, with castration usually being done first. Very strict sanitary conditions should be followed when castrating lambs, and they should be placed in a clean, dry pen or on clean pasture following the operation.

The castrated male lamb is known as a wether.

D. Castration of Horses

A colt may be castrated at an earlier age, however, most horsemen prefer to postpone the operation until the animal is at least one year of age. Although there is less set back and less danger to the animal when early castration is practiced, leaving the colt as a stallion for a time will result in more muscular, bolder features. Also, it will result in better development of the foreparts.

There will be less danger of infection if colts are castrated in the spring when they are running on clean pastures. Regardless of the age, time, or place, castration should be done by an experienced veterinarian.

The castrated male colt is known as a gelding.

II. Methods of Castration

The methods and procedures used for castrating the different species of livestock will vary depending on the operator and the size and kind of animal being castrated. Basically, there are two ways in which castration is performed: (1) Surgical removal of the testicles with the use of a knife or scalpel and (2) Bloodless castration by the use of either the burdizzo or an elastrator.

Transparency No. 1

A. Castrating with a knife or scalpel is the method most commonly used on cattle and sheep, and it is used exclusively on swine and horses. When castrating by this

method, the operator should follow strict sanitation practices. They should disinfect all equipment and instruments used in the operation.

When castrating by this method, after the lower portion of the scrotum has been removed, or the sides of the scrotum have been slit by use of a knife or scalpel (whichever procedure is followed), then the membrane covering each testicle is slit and the testicles are pulled out. In older animals, excessive bleeding may be prevented through severing the cord by scraping with a knife or clamping with an emasculator. The action of the emasculator crushes the spermatic cord and artery and prevents blood hemorrhage. Two types of emasculators are shown, each of which performs essentially the same job, except the improved model has a double crushing blade. Before castration is performed, the area around the scrotum should be washed and scrubbed with soapy water (if needed), and a disinfectant should be applied to the area. Also, the operator should wash their hands before beginning the operation.

Transparency No. 2

B. Bloodless Castration

1. Burdizzo--Use of the burdizzo for the castration of cattle and sheep is a satisfactory method if done properly and by an experienced operator. This is a bloodless method in which the testicle cords are severed by use of the burdizzo. This operation destroys the channel of nourishment to the testicle, and after a time the testicle will wither away and be absorbed by the body. The skin is not broken and there is not an open wound through which infection may occur by this method.

2. Elastrator--The elastrator is an instrument used to stretch a specially made rubber ring over the scrotum of young calves or lambs. This stops the circulation of blood to the testicles and causes them to atrophy and drop off.

   This method is for use on smaller animals while application to animals too large for the practice may cause only partial stoppage of circulation, thus leading to infection and possible death loss.

III. Procedures for Castrating

The generally accepted methods of castrating and castrating equipment have been covered above, so in discussing procedures for castrating the different species of livestock all of the equipment will not be shown.

Transparency No. 3

A. Castrating Cattle

Any one of the three methods of castration discussed may be used for castrating bull calves. However, a majority of cattlemen use the knife, particularly when there is no danger of flies or screw worms.

Proper restraint of the calf at the time that castration is to be performed is important. When mechanical cattle handling facilities are available, the animal may be secured on a tilt table or a calf working table in a chute. Otherwise, restraint may be accomplished by stretching the animal between two poles by use of ropes or simply by hand restraint as shown on this transparency.

1. There are two methods of castrating cattle using the knife; the main differences between the two is the place of the incision or slit in the scrotum.

   a. The first method discussed will be the removal of the lower end of the scrotum. The bottom of the scrotum is held in the left hand, stretched tightly, and the bottom one-third of the scrotum is cut off. Thus, the ends of the testicles are exposed. The testicles are pulled out and cut one at a time. The membrane covering each of the testicles may be slit before severing the cord for removal of the testicle, or it may be removed along with the testicle. Removal of the membrane eliminates the possibility of it collecting blood and forming a clot. The spermatic cord should be cut about three inches above the testicle. To prevent drainage restriction, which is caused by swelling and a curling up of the scrotum tissue, the scrotum may be slit on the sides. In older animals, six months or older, the cord may be severed with an emasculator, or the cord may be twisted and severed by scraping it back and forth with a knife or scalpel.

   b. The second method is to slit each side of the scrotum on the outside next to the animal's leg. The incision or slit is made parallel to the middle line or membrane dividing the scrotum. It is important to extend the incision well down to the end of the scrotum to allow for proper drainage. The membrane surrounding the testicle may or may not be slit before removing the testicle, but a major portion of the membrane should be removed along with the testicle to keep it from collecting blood.

The testicles are removed by grasping and pulling them out. The spermatic cords are cut in the same way as described in the first method. In older cattle, excessive bleeding may be prevented by severing the cords with an emasculator. This method of castration is recommended for castrating animals while they are standing.

(Refer back to Transparency No. 2 for illustration of the Bloodless Methods of Castration.)

2. Both methods of bloodless castration may be used on cattle.

   a. To castrate the animal by the burdizzo method, the spermatic cord should be worked to the side of the scrotum and clamped about one and one-half to two inches above the testicles. The clamp should be held in a clamped position for a few seconds to make sure the cord is crushed. After clamping one cord, the procedure should be repeated on the other cord. If the cord is not completely crushed, the animal will develop a staggy looking appearance. The operator should allow the circulation of blood to the end of the scrotum. To allow for this circulation, an area should be left between the clamp marks made on the scrotum.

   b. The other bloodless method of castrating requires the use of an elastrator. The elastrator is an instrument used to place a rubber band above the testicles which stops the circulation of blood to the testicles and causes them to atrophy and drop off. This method of castrating, which is objectionable to some cattlemen, results in a smaller cod. Remember, this method is for use on smaller animals, perferably young calves under 2 months of age.

B. Castrating Sheep

Ram lambs may be castrated by the same methods used for castrating calves. Remember castration should be done when the lambs are from 7 to 14 days old. The castration should be done only on a bright clear day--never when it is damp and chilly.

Transparency No. 4

Restraint of a lamb for castration by the holder may be done in either a standing or sitting position. If the holder is in a standing position, the lamb's two right legs are held in the right hand, the two left legs are held in the left hand, and the lamb's back is held against the holder's body.

Some operators prefer to have the lamb's rump resting on a castration table while being held in this position, particularly when docking is being done at the same time.

When the holder is in a sitting position as illustrated on the transparency, the lamb's legs are held in the same manner described above, while the lamb's back is supported between the holder's legs.

1. Using a knife--The most common method of castrating lambs is to cut off the lower one-third of the scrotum. The testicles are then exposed by applying pressure at the base of the scrotum near the abdomen. The exposed testicles are removed by grasping them with either thumb and crooked forefinger of the right hand or the teeth, and then pulling gently until the cord breaks.

   Following castration by this method, the proper precautions should be observed to protect the open wound against infection or fly infestation.

2. Bloodless castration may be performed on lambs by use of the "burdizzo" or an elastrator. When the burdizzo is used, the operator should use the recommended size for castrating lambs. Also, they should perform the operation carefully to observe that the spermatic cords are completely severed, otherwise lambs may become staggy as they grow older.

   The elastrator may also be used successfully for castrating lambs. Rubber bands are slipped over the scrotum near the base of the abdomen and circulation is cut off, thus causing the scrotum and testicles to gradually wither and drop off.

C. Castrating Hogs

There is no bloodless method of castrating hogs, and a knife or scalpel must be used to slit the scrotum.

Transparency No. 5

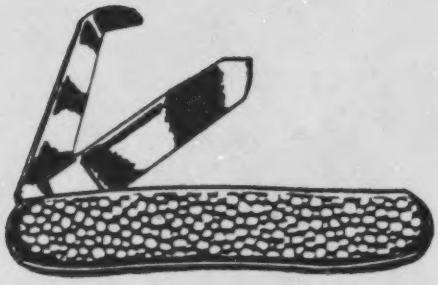
The method used to restrain hogs for castration will be determined by the size of the hog. The method shown on this transparency is satisfactory for restraining pigs. When mature boars are castrated, it is usually best to throw them and tie their legs. Sanitation is particularly important when castrating hogs.

Since the testicles of hogs are hard to hold and keep in place when castrating, the following explanation is given for holding them. If the hog is being held on its back, the right-handed operator should position themselves next to the hog's right hind leg and face the under side or testicles of the hog. The finger next to the index finger on the left hand is used to push the testicle toward the rear of the hog. While pressure is applied with this finger, the testicle is gripped with the index finger and thumb. Using the right hand to hold the testicle, the left-handed operator would follow the same procedure from the opposite side of the hog. The testicle farthest from the operator should be removed first. An incision should be made on the scrotum over the testicle parallel to the median line. The length of the slit is made, the testicle is pulled out and the spermatic cord is cut or scraped into. The procedure is repeated on the testicle next to the operator. Usually one stroke of the knife is required to cut the scrotum and membrane by the experienced operator. To prevent excessive bleeding in older hogs, the operator should use the emasculator to cut the cord. If fly season, apply an insect repellant to the wound.

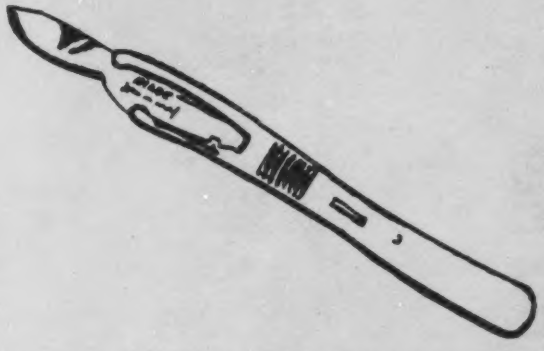
D. Castrating Horses

Most authorities recommend that horses be castrated by a veterinarian. The time to castrate is important and should be determined by the horse's development. Most horses are castrated as yearlings, but those that develop slowly may be left entire for a longer period.

CASTRATION INSTRUMENTS

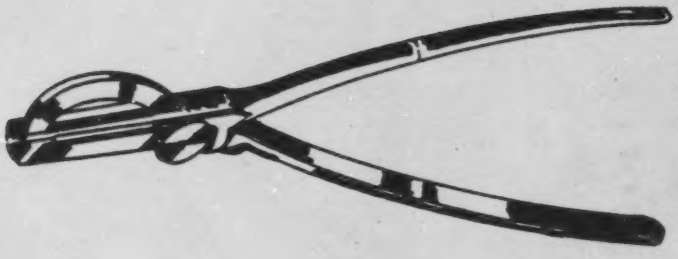


CASTRATION KNIFE



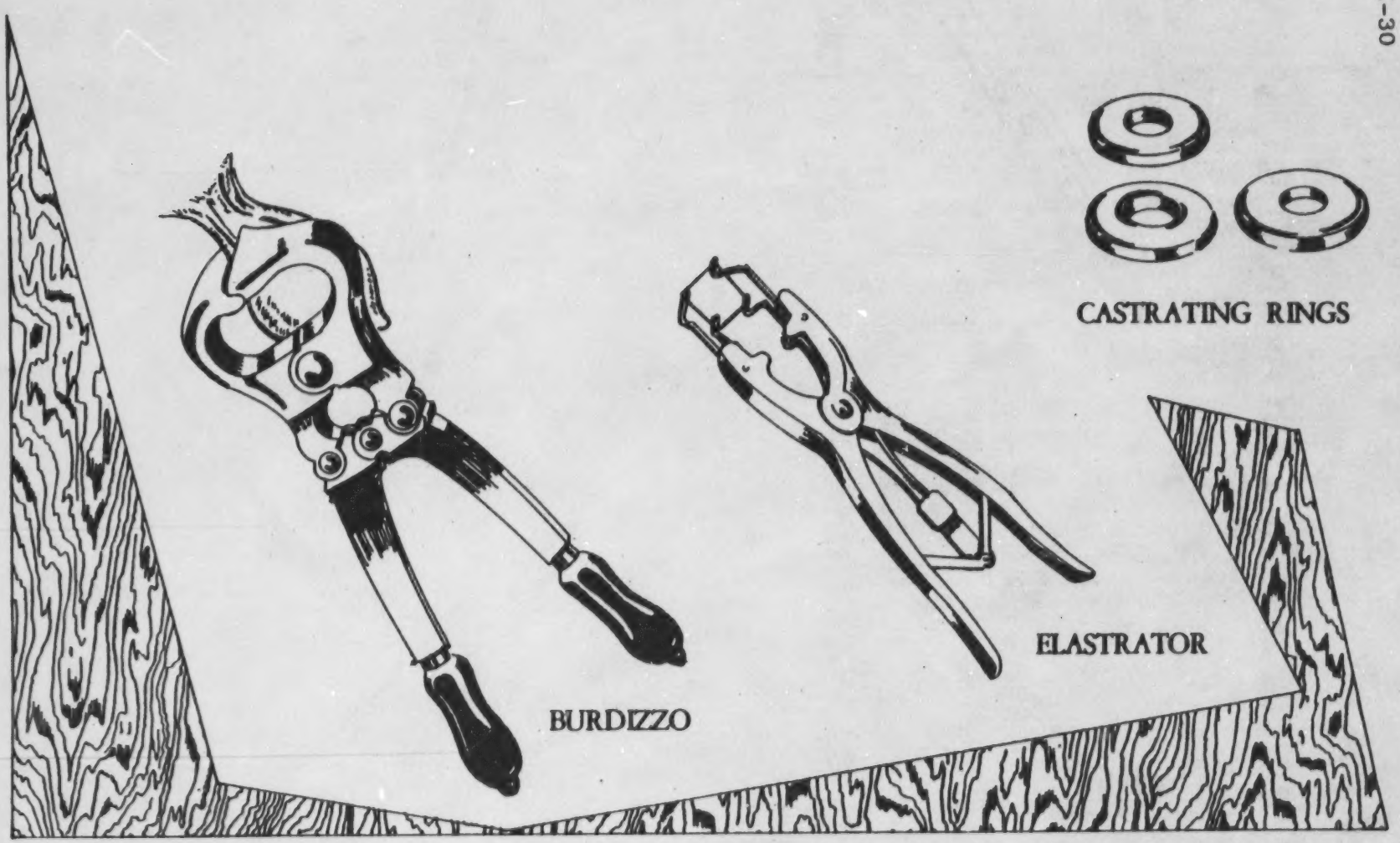
CASTRATION SCALPEL

IMPROVED EMASCULATOR



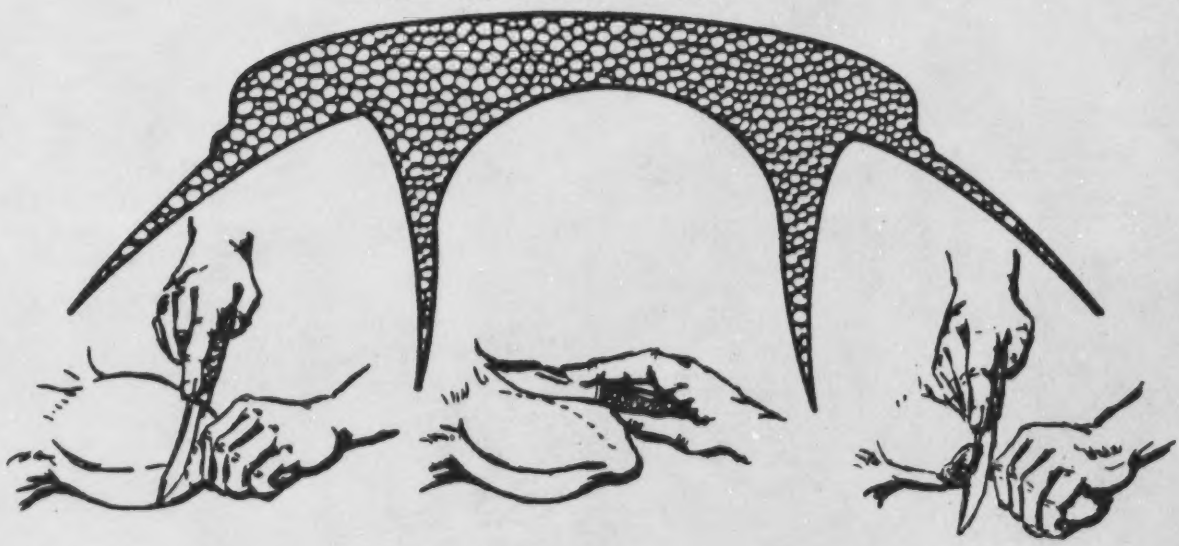
PLAIN EMASCULATOR

BLOODLESS METHODS OF CASTRATION



CASTRATING CATTLE

CASTRATING RESTRAINT



CASTRATING WITH A KNIFE

CASTRATING SHEEP

RESTRAINT

USE OF KNIFE

USE OF BURDIZZO

USE OF ELASTRATOR

CASTRATING SWINE

REMOVING TESTICLE

RESTRAINT

TM-5

AgII-XIII-33

Glossary of Terms:

Atrophy - Following the use of the elastrator for castration, the scrotum and testicles will decrease in size or finally wither away due to the blood supply being cut off.

Testosterone - Androgenic hormones produced by the interstitial cells of the testes (testicles). It is the male sex hormone which stimulates the development of the male reproductive organs, growth processes, and certain parts of the male anatomy.

Scrotum - In livestock, it is the sac outside the body proper in which the testicles are located. Besides providing protection for the testes, the scrotum functions as a heat regulating mechanism so that live, viable sperm can be produced in the testes.

Spermatic Cord - The smooth muscle and connective tissue which provides the passageway for sperm produced in the testes and through which semen passes to the urethra. This cord is severed at the time of castration to stop the flow of blood to the testicles.

Student Activities:

1. What two functions of the testicles are eliminated as a result of performing castration on the male?

   a.

   b.

2. For what reasons have livestock breeders practiced castration of livestock?

   a.

   b.

   c.

3. At what age is castration recommended for each of the following kinds of livestock?

   a. Cattle -

   b. Swine -

   c. Sheep -

   d. Horses -

4. Give the name of the castrated male for each of the animals listed.

   a. Bull -

   b. Boar -

   c. Ram -

   d. Stallion -

5. What are the two general methods of castration practiced for the different species of livestock?

   a.

   b.

6. Identify and spell correctly each of the castration instruments shown below.

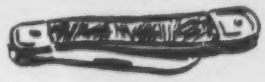
a._____

b._____

c._____

d._____

e._____



7. Castrating with a knife or scalpel is practiced exclusively on two of the animal types mentioned in this topic. They are:

   a.

   b.

8. When using the knife for castration, what procedures may be followed to prevent excessive bleeding?

9. Which of the methods of bloodless castration would be least designed for use on older, larger animals?

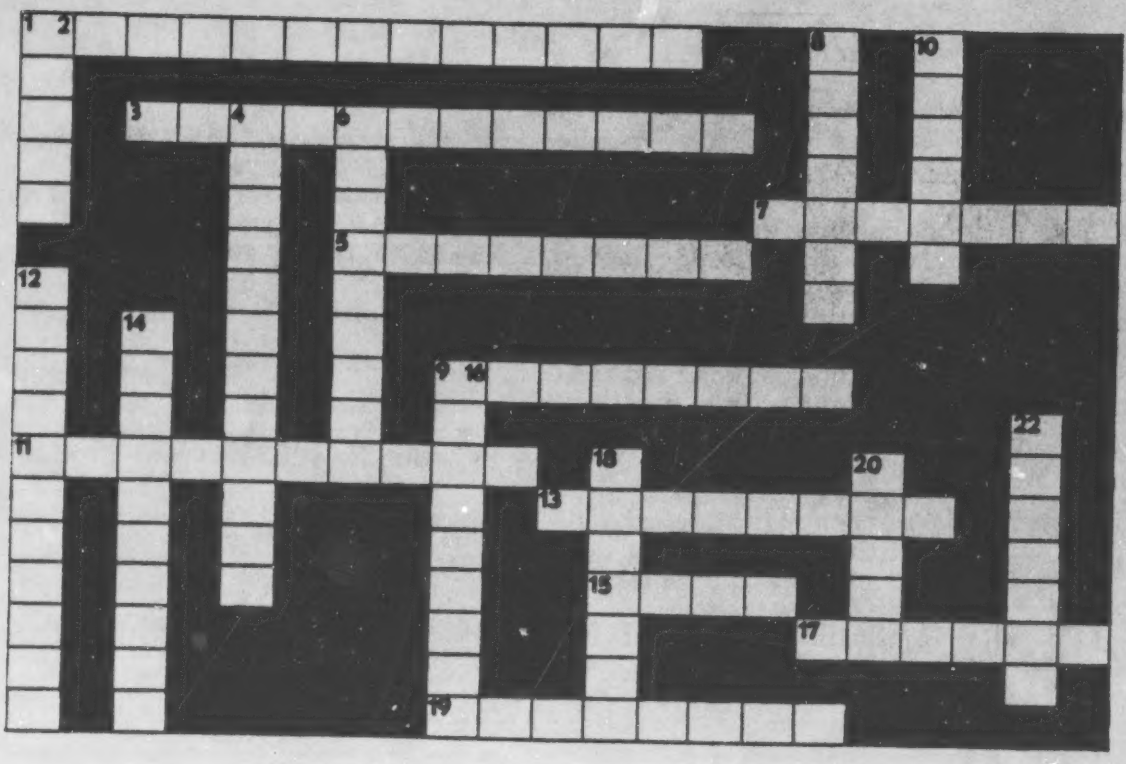
   a. Burdizzo or Elastrator _____

   b. Give an explanation for your choice.

10. Which type of livestock mentioned in this topic is slower in reaching sexual maturity and therefore is generally castrated at an older age?

11. Why might the use of the elastrator and rubber band be a less desirable method for castrating a show steer?

12. What is the general recommendation given regarding the castration of horses?



13. Crossword Puzzle

Across:

1. Tubular structure providing passageway for sperm produced in the testicle. _____ _____
3. Licensed practitioner who should be contacted regarding castration of livestock, particularly horses.
5. Male sex organ responsible for the production of sperm.
7. The withering away of the testicles following castration by the bloodless castration procedure.
9. Mechanical instrument used for bloodless castration where the cords are pinched in two and the skin is not broken.
11. The process of removing the sex organs (testes) from the male.
13. Age in development at which most colts are castrated.
15. To remove part of the sheep's tail.
17. A castrated male sheep.
19. Method of castration involving use of a sharp instrument to make an incision for removal of the testes.

Down:

2. A castrated bull.
4. Male sex hormone responsible for development of sex organs and male behavior.
6. Act of controlling the physical movement of animals while castrating.
8. Sac in which the testicles are located.
10. A castrated boar.
12. Instrument used in the surgical castrating procedure for crushing the cord so that a minimum of blood is lost.
14. Castrating instrument used for applying the rubber bands used in bloodless castration.
16. A method of castrating whereby the testicle is not surgically removed.
18. A castrated stallion.
20. Instrument commonly used by most stockmen when performing castration.
22. Instrument which is used by most veterinarians when castrating by the surgical method.

14. What are the reasons given for docking sheep?

a.

b.

c.

15. List the methods that can be used for docking lambs.

a.

b.

c.

d.

e.

16. How might the practice of docking the tails of ewe lambs at two inches and docking the tails of ram lambs at four to six inches assist the sheep producer at weaning time?

17. Visit the business establishment of a veterinarian to observe the castration of livestock and docking of sheep as the opportunity presents itself.

18. Use opportunities that may be afforded in class laboratory experiences or on the home farm to witness and gain actual experience in castrating and docking procedures.

LIVESTOCK SKILLS

Topic 3: Dehorning

*Terms: All terms underlined are in the "Glossary of Terms."

I. Advantages of Dehorning

Because of the attractiveness of a properly trained set of horns, the purebred breeders of horned cattle do not dehorn; however, most commercial cattlemen prefer that their cattle be dehorned. Some of the advantages of dehorning cattle are as follows:

A. Less feed and shed space are required for dehorned animals.

B. Equipment for handling cattle needs fewer repairs and lasts much longer with dehorned cattle.

C. Dehorned cattle have fewer bruises; horned cattle, both beef and dairy, inflict more injuries to other cattle in the herd; there are definitely fewer udder injuries in dairy herds of dehorned cattle.

D. Dehorned feeder cattle tend to gain faster, are quieter, and are easier to handle.

E. There is less change of injury to the stockman handling dehorned cattle.

F. Dehorned cattle usually sell for one to two cents per pound more than horned cattle.

II. Age to Dehorn

Age is an important factor in dehorning and often determines the method to be used. Young animals are easier to handle than older ones. The after effects younger calves suffer are usually slight, and when done properly the first time, never needs repeating.

It is best to select a cool, sunshiny day for the operation during a time of the year when flies are not a problem.

III. Methods of Dehorning

The method a stockman will use to dehorn will be determined by the age of the animal, the size of their horns, equipment available, and available labor. The two methods of dehorning may be classified as chemical and mechanical.

A. Chemical Dehorning

Transparency No. 1

The use of chemicals to burn the horn buttons and prevent growth is more successful when used on calves before they are ten days old. The most commonly used chemicals are caustic soda or potash, and they are usually available in a paste or stick form. The caustic should be applied with caution to prevent injury to the stockman and excessive burning to the animal. The caustic method of dehorning is used mostly in small, closely supervised herds.

To prepare the calf for dehorning, the stockman should clip the hair around the base of the small, undeveloped horns or buttons and apply about a one-half inch band of petrolatum on the hair at the base of the horn button. The petrolatum will prevent the caustic from severely burning the skin. If the caustic stick is to be used, the stockman should wrap paper around one end of the stick; and the stick should be held by the paper. Either the stick or the horn button should be moistened, and the horn button should be rubbed with the stick. Excessive moisture, either on the stick or horn button, will cause the caustic to run. If the paste is used, a stick may be used to apply the paste. Using the stick or the paste, the stockman should apply about 1/16 inch thickness of caustic to the horn button.

B. Mechanical Dehorning

Instruments used for dehorning should be cleaned and disinfected before and after each operation to prevent the introduction and spread of infections and contagious diseases. This is especially important where anaplasmosis is prevalent or suspected.

The instruments should be washed in cold water to remove blood. After the instruments are washed, they should be soaked in a disinfecting solution. A solution of four ounces of cresol to one gallon of water makes a good disinfecting solution (for other disinfectant solutions ash your veterinarian, a veterinarian supply store operator, or local stockmen).

The type of dehorner used will determine how the cattle are handled. If the cattle are going to be worked in a squeeze chute, the operation is simplified because the cattle do not have to be held by hand or thrown.

Transparency No. 2

1. Hot Iron Dehorning

There are two kinds of hot iron dehorners; those that are heated by electricity and those dehorners, called

dehorning coppers, that are heated by some kind of fuel. Regardless of the type used, the stockman should select one that is large enough to cover the horn button. Most electric dehorners are available in only one size, but the copper irons can be purchased in several sizes.

Hot irons can be successfully used on calves after they have passed the button stage and until they are two to three months of age. One of the best methods of restraining the calf for dehorning with the hot iron is to place the calf against a good broad fence, and with the halter rope, pull the calf's head above its body so that it can place very little of its weight on its front feet.

After the irons are heated, the stockman should place the dehorner over the horn and hold the hot iron firmly against the head for 15 seconds. This destroys the horn growth cells around the base of the horn, and the horn will usually slough off in about a month to six weeks.

2. Spoon and Tube Dehorners

Dehorning spoons and tubes are recommended for use on calves up to about three months of age. At this age the horns are still skin appendages and can be scooped out rather easily. Dehorning tubes vary in size and can usually be bought in sets of four. The tube should be large enough to fit over the horn and cover about 1/8 inch of skin around the horn.

Placing the cutting edge straight down over the horn, the operator should push and twist the tube until the skin has been cut through; then should use the cutting edge of the tube to cut under the horn button and to remove it.

The dehorning spoon or gouge is used to gouge out the horns on young calves. With a little experience, a stockman can do a fast and efficient job of dehorning with the spoon.

3. Elastrators

The elastrator, an instrument used to stretch a special rubber band, has been used in dehorning cattle. The rubber band is put over the horn and placed into the hair line. This method of dehorning is used on cattle with horns from three to six inches long. Some cattlemen have been disappointed with the results they have received from this method of dehorning.

Transparency No. 3

4. Barnes-Type Dehorners

Barnes-type dehorners are available in two sizes. The smaller size is used on calves four to eight months of age, and the larger size is used to dehorn yearlings or older cattle.

When using this type of dehorner, the stockman should restrain the animal in such a manner that enough pressure may be applied to properly use the dehorner. To use the Barnes-type deborner, the stockman should close the handles and fit the knives over the horn. The knives should be positioned so that they will remove a ring of skin with the horn. After the dehorner is placed in the proper position, the operator spreads the handles apart quickly, thus closing the knives and removing the horn.

5. Dehorning Clippers

Dehorning clippers are preferred by most stockmen because they are faster, easier to use, cause less pain to the animal, and make a smoother cut. Saws should be used on abnormally large horns and on older cattle when there is a possibility that the clippers will crush or sliver the horn. An electric saw dehorner, which is similar to a portable electric wood saw, can now be purchased. The animal can be dehorned much faster with this type of dehorner, but it is expensive and difficult to disinfect.

When using the clippers, the stockman should place the opened blade over the horn so as to remove about 1/2 inch ring of skin with the horn. The deep cut destroys the modified skin cells from which horns grow. After the clippers are placed in the proper position, the stockman should quickly close the handles and clip off the horn.

6. Dehorning Saws

If either hand or electric dehorning saws are used, the operator should cut deep enough to remove a ring of skin and prevent later growth of abnormal, unsightly horns. If the stockman so desires, a local anesthetic can be administered to eliminate the pain caused by the saw in the dehorning operation.

IV. Preventing Excessive Bleeding

There are several recommended methods of preventing excessive bleeding in animals dehorned by a mechanical method that causes bleeding.

The operator may use gauze or tissue paper and a commercial blood stopper to prevent excessive bleeding in young animals. The gauze or paper is folded into a pad several layers thick and about 2½ inches in diameter. After the blood stopper has been applied, the operator places the pad over the dehorn wound and holds the pad in place for a short time. The pad, which causes the blood to clot, is usually held in place by the dry, clotted blood.

Bleeding in larger animals can be minimized by using forceps to pick up the main artery on the ventral, or underside of the cut. The artery should be pulled until it breaks; the broken artery will retract and go back into the soft tissue, thus stopping the bleeding.

V. Care of Animals After Dehorning

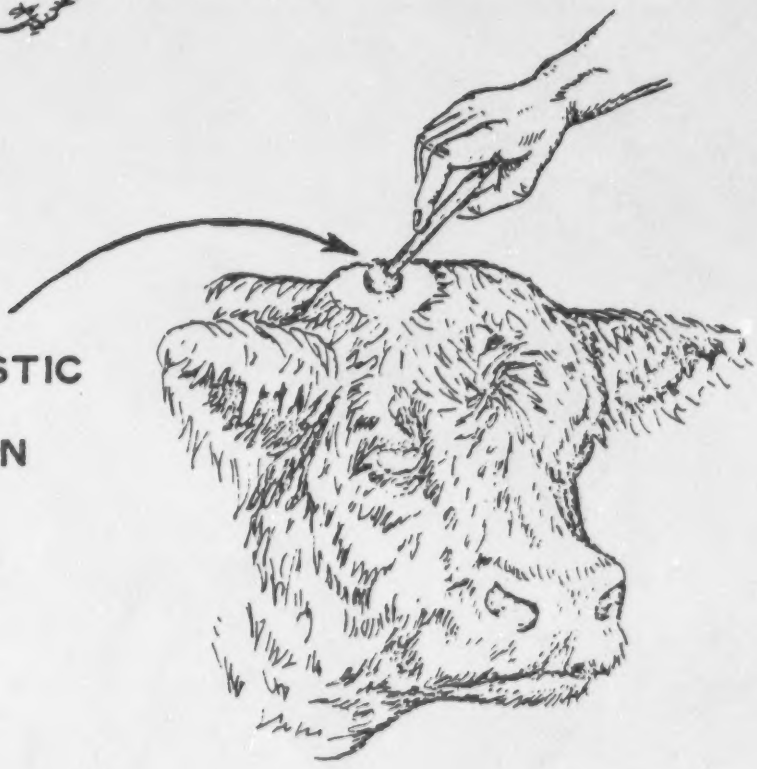
The animals should be kept in a small pasture or trap for the first week after dehorning. The stockman should observe the animals periodically for infection. There is a tendency for animals to become wild after dehorning. To gentle the animals, the stockman should feed a small amount of feed each day while they are in the small pasture.

AgII-XIII-44

CHEMICAL DEHORNING

CLIP HAIR &

APPLY PETROLATUM



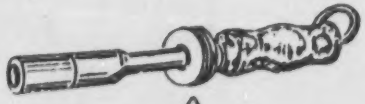
APPLY CAUSTIC

TO BUTTON

TM-1

DEHORNERS

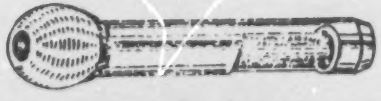
hot iron



electrical

DEHORNING IRONS

METAL SPOON
OR GOUGE



TUBE DEHORNER

ELASTRATOR

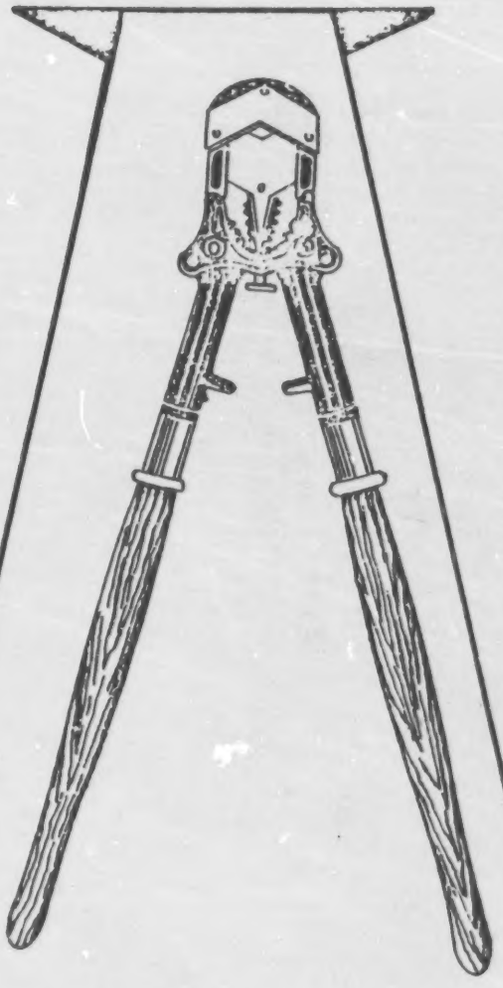
TM-2

AgII-XIII-45

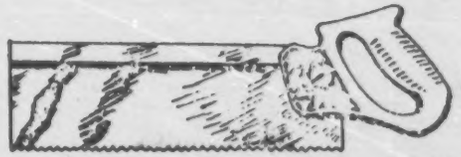
DEHORNERS

AgII-XIII-46

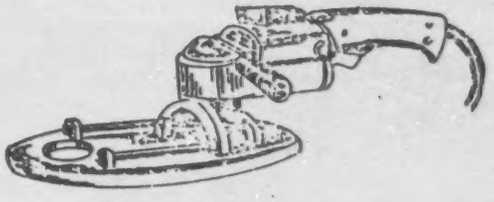
"BARNES TYPE"
DEHORNER



DEHORNING CLIPPERS



hand



electrical

DEHORNING SAWS

TM-3

850

851

Glossary of Terms:

Anaplasmosis - An infectious disease caused by a parasite which invades the red blood cells. It can be spread by dehorning infected animals and then using the dehorning instrument on other animals without properly disinfecting it.

Buttons - The small undeveloped horns of the calf before they penetrate the skin.

Local Anesthetic - A drug formulation that is used to produce loss of feeling to a limited area of the body; in this case, the anesthetic would be applied near the base of the animal's horns.

Petrolatum - An odorless, tasteless substance obtained from petroleum and used in ointments and dressings.

Student Activities:

1. What are some of the advantages given for dehorning?
   a.
   b.
   c.
   d.

2. What is the most desirable age to dehorn?

3. What factors usually determine the method of dehorning that is best to use?
   a.
   b.
   c.
   d.

4. What are the chemicals that are most commonly used in the caustic (chemical) method of dehorning?
   a.
   b.

5. Explain briefly the general procedures followed in chemical dehorning.

6. List the various types of instruments that can be used for mechanical dehorning.

   a. d.

   b. e.

   c. f.

7. Why should the dehorning instrument be cleaned and disinfected before and after each operation?

8. Approximately how long should the hot iron dehorning instrument be held against the base of the horn?

9. What type of dehorning instrument is best suited and generally used on calves four to eight months of age?

10. What type of dehorning instrument is recommended for use on older cattle that have abnormally large horns?

11. How close to the animal's head or how deep should the horn growth be removed to prevent later growth of abnormal, unsightly horns?

12. What can the operator do to eliminate the pain caused by the use of the saw in the dehorning operation?

13. Briefly explain the two methods that are commonly followed to prevent excessive bleeding in animals dehorned by the mechanical methods.

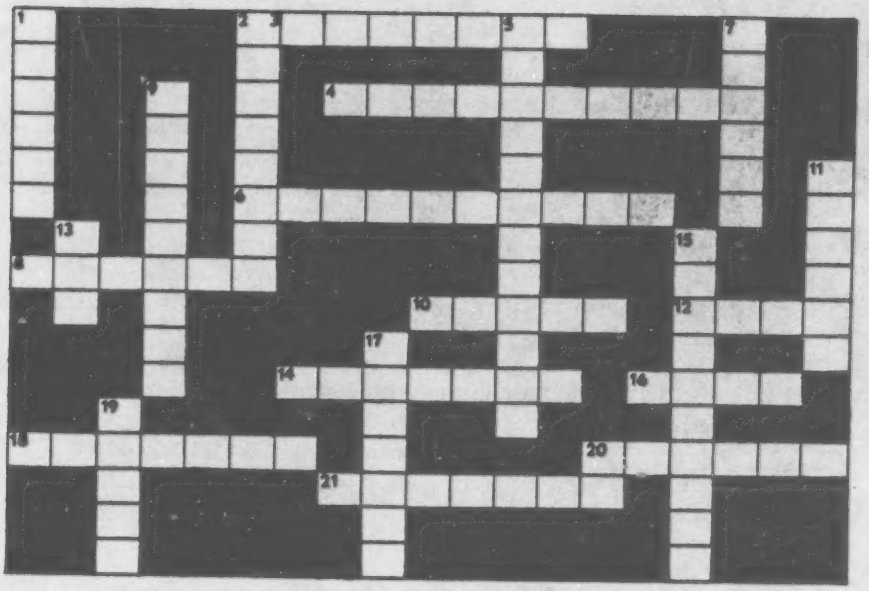
14. What precautions should be observed in caring for animals after dehorning?

    a.

    b.

    c.

15. Use opportunities that may be afforded in class laboratory experiences or on the home farm to witness and gain actual experience in the various dehorning procedures.



16. Crossword Puzzle

Down:

1. A disinfectant that is recommended for sanitizing mechanical dehorning instruments.
3. Dehorning instrument preferred by most cattlemen, especially on mature cattle.
5. An infectious disease that may be spread in the dehorning process if proper care is not given to disinfecting instruments.
7. Cattle that are naturally hornless are said to have this characteristic.
9. A livestock management practice not commonly performed on purebred cattle.
11. Dehorning irons are sometimes called dehorning _____ (singular).
13. Dehorning instruments recommended for use on cattle with extra large horns.
15. Dressing applied to the base of the horn when using the chemical dehorning method.
17. Undeveloped horns of the calf.
19. Anesthetic used to reduce sensitivity at a limited area of the body is said to be _____.

Across:

2. Dehorning method successfully used on baby calves.
4. Dehorning method requiring instruments which actually remove the animal's horns.
6. Mechanical dehorning instrument for applying rubber band around the horn.
8. Mechanical dehorning instrument more suitable for older calves and yearlings.
10. Mechanical dehorning instrument recommended for use on calves up to three months of age.
12. Mechanical dehorning instrument recommended for use on calves up to three months of age.
14. Chemical commonly used to burn the horn buttons on calves under 10 days of age.
16. Chemical commonly used to burn the horn buttons on calves under 10 days of age.
18. To prevent excessive bleeding, a commercial blood _____ may be applied to the animal's head after dehorning.
20. Abbreviation for Southwest Animal Health Research Foundation.
21. Instrument used to pull the exposed arteries when excessive bleeding occurs after dehorning.

LIVESTOCK SKILLS

Topic 4: Branding, Marking, Ear Notching, Tagging and Tattooing

*Terms: All terms underlined are in the "Glossary of Terms."

I. Importance of Animal Identification

Branding and marking of livestock to give a permanent mark of identification and to establish ownership has been practiced since early times. The first branding used in some parts of the world was for the purpose of permanently marking human criminals. Early livestock producers used other methods in addition to branding to identify their animals; some of these were dewlap tag brands, wattles, and ear marks. Branding, marking, ear notching, tagging, and tattooing are the principal methods used to identify animals today.

Even though there have been many changes in the production of livestock most cattlemen still brand. For fast easy identification, purebred breeders of horned cattle horn brand, and breeders of polled cattle either hide brand, use neck chains, or use ear tags. Most commercial cattlemen, particularly those with large herds, brand their livestock.

All livestock producers take great pride in their brands, for this is a symbol of quality, service, and integrity. Also, it is necessary for many commercial stockmen to brand so that they can keep accurate herd records.

II. Branding

All kinds of livestock may be branded; however, more cattle are branded than any other kind. While cattle may be branded at any age, younger cattle are easier to handle. It is a practice in the western states to brand, castrate, and vaccinate at the same time; this practice eliminates the handling of animals more than once. Calves that are kept as replacements are branded, while those to be sold are not.

There are two general types of branding irons, "running irons" and "stamping irons." Whether letters, numerals, or characters are used, they should be easily made and constructed of steel or copper. Hot irons should be made from steel or copper stock large enough to hold the needed heat. Three-eighths inch stock is recommended. Irons used for freeze branding can be made from steel or copper, but copper irons cool faster and transfer

the cold more rapidly. Handles on hot irons should be long enough, two to two and one-half feet, to permit easy handling. Irons used for liquid branding may have shorter handles and are usually curve faced.

Most states require that brands be recorded with the state. The stockman should have their brand and earmark recorded in all counties in which they graze livestock.

The brand should be located so that it can be easily seen and applied but placed in an area that will cause the least possible hide damage. A brand that is approximately four inches tall is considered large enough, especially if the animal is branded while young.

Transparency No. 1

The three methods used to brand livestock are a hot iron, a commercial branding fluid, and a freeze brand. Regardless of the method used, the animal should be dry when branded. Branding a wet animal with a hot iron will leave a blotch, a scald, a bad sore, or no imprint at all. If a wet animal is branded with the liquid branding fluid, the fluid will run, cause excessive burning, and probably mar the brand.

A. Hot Iron Branding

Two kinds of hot irons may be used for branding: the electric branding iron and those that require fuel to heat them.

After the animal has been restrained in such a manner that the brand can be applied and the iron has attained the proper heat (ash gray for steel irons heated with fuel), the stockman, being careful not to let the iron slip, should hold the iron to the animal's skin long enough to scorch the skin surface. A good brand will peel and remain distinct. Deep burning is cruel and unnecessary.

Using a much smaller iron, the stockman should follow the same procedure for horn branding as that used for hide branding. Horn branding of older animals is usually successful, but the branding of animals with growing horns usually has to be repeated.

B. Liquid Branding

To prepare the animal for liquid branding and to secure the best results, the stockman should clip the hair from the area on the animal where the brand will be applied.

The branding iron is dipped in 1/8 to 1/4 inch of commercial branding fluid and pressed against the skin for a few seconds. It is difficult to control the depth of burning with a liquid branding fluid. If too little is applied, the imprint will soon disappear. If too much is applied, a bad sore will result, or the spreading of the excess liquid will cause a blurred imprint. Liquid branding is generally not considered as satisfactory as hot iron branding.

C. Freeze Branding

Freeze branding is a recently developed method of branding that appears to be a successful means of permanently marking animals for identification. Laws in some states specify that animals must be hot iron branded; it will be necessary to change the laws before freeze branding can be used in these states.

To prepare the fluid necessary for freeze branding, the stockman should use golf ball size chunks of dry ice and pour denatured alcohol over the ice. The proportion of dry ice to alcohol does not have to be accurate, and only enough alcohol is needed to cover the characters of the branding irons. Enough ice is needed to chill the alcohol. To avoid sludge in the mixture, the stockman can use any of the following alcohols: 95% methyl, isopropyl, ethyl, or acetone. The mixture stabilizes at 90 degrees; at this temperature evaporation of the alcohol is negligible. As the dry ice and alcohol are mixed, the mixture will bubble and foam for two or three minutes; the mixture is ready for branding after it stops bubbling and foaming.

In preparation for branding, the hair should be clipped from the area to be branded. Too much hair forms an insulating barrier that often causes poor results. To prevent the cold iron from sticking to the animal, the stockman should prepare the area to be branded by wiping it with alcohol. The branding irons should be left in the solution for two or three minutes or until they are chilled. The iron is held on cattle for 30 seconds and on horses for 20 seconds. Holding the iron to the animal for this length of time will destroy the color producing cells, called melanocytes, and will cause the hair to grow out white. The hair will not turn white immediately, but the new hair which grows from the brand will be white. This process will not brand a white animal; however, if the stockman will hold the iron to the white animal's skin for 50 seconds, the hair follicles will be destroyed. The hair will fall out and leave a clean, hairless brand.

A freeze brand is much easier to apply than other brands, and it does not destroy the hide where the brand is applied.

III. Marking Animals

It is a common practice to earmark cattle, sheep, goats, and swine. Earmarks are secondary to brands but should be recorded along with the stockman's brand, which is protected by law. While it is often impossible to get the side view of an animal, the stockman marks animals so that they can identify them from the direct front or rear. For this reason, marking is about as widespread as branding.

Transparency No. 2

Since the cartilage of the ear is tough, the stockman must use a sharp knife to get a clean cut.

IV. Ear Notching

Ear notching is a system of numbering animals that is required by some breed associations in addition to the requirement that the animal be tattooed or ear tagged. Ear notchers may be purchased in several different sizes.

Transparency No. 3

A simple ear notching system and one that is recommended by one of the major swine breed associations is as follows: The system consists of four numbers--one, three, ten, and thirty.

a. One notch in the lower right ear is number 1.
b. One notch in the lower left ear is number 3.
c. One notch in the upper right ear is number 10.
d. One notch in the upper left ear is number 30.

If a producer will remember these four notches and the numbers they stand for, they can recognize a number or identify an animal instantly. The following is an example of the above numbering system: To number an animal eighteen, a stockman would notch the upper right ear for 10, make two notches in the lower right ear for 2, and make two notches in the lower left ear for 6.

The term "lower" refers to the "outside" or bottom side of the ear, and the term "upper" refers to the "inside" or top part of the ear.

Transparency No. 4

V. Ear Tags

The ear tag, usually made from either metal or plastic, is another method of idendifying animals and is required by some breed associations. Special instruments are required to apply most ear tags which contain the owner's name or initials,

the animal's number, and the year the animal was born. Ear tags are easy to apply, and they are also easy for animals to lose and should not be considered a permanent identification.

VI. Tattooing Livestock

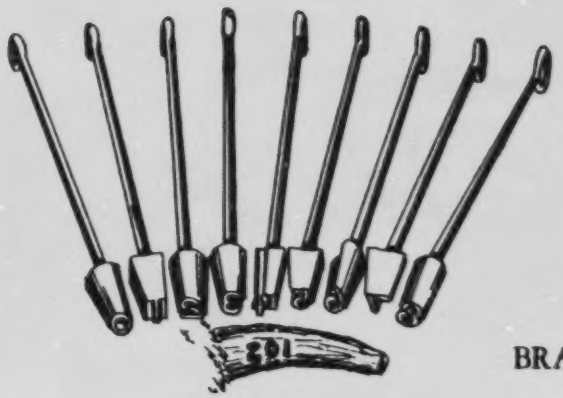
The tattooing of livestock is a permanent method of identification required by most purebred cattle breed associations, and lip tattooing of horses is required by the Jockey Club.

The tattooing of cattle is done with a special instrument that places characters, letters, or numerals in and under the skin of the ear by means of a series of needle like points.

The stockman should disinfect the tattooing instrument and clean all the wax from the area to be tattooed. The tattoo should be placed in the center inside of the ear and not on a midrib or blood vessel. Placing the tattoo in a blood vessel will cause excessive bleeding, and it will become indistinguishable and blurred. After a special indelible ink is applied to the needle like points, the instrument is placed in the ear and pressure is applied so that the points perforate the ear. The stockman should rub indelible ink, which will have a permanent tattoo, into the perforations.

Horses are tattooed in the same manner, but the tattoo is placed on the inside of the upper lip.

METHODS OF BRANDING LIVESTOCK



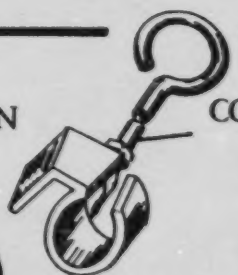
HORN IRONS

BRANDING IRON HEATER

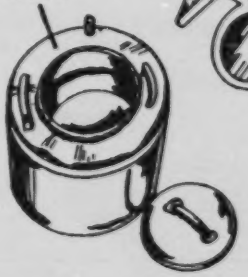
ELECTRIC IRON

1 Hot Iron Branding

STEEL OR COPPER IRONS



COPPER IRON



LIQUID NITROGEN TANK

2 Freeze Branding

3 Liquid Branding

861

862

TM-1

COMMON EAR MARKS

UNDER BIT

OVER BIT

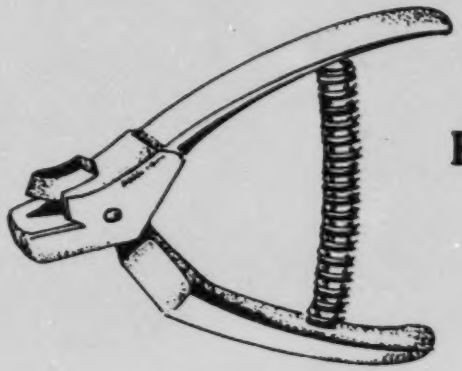
SWALLOW FORK

SPLIT

BOBBED

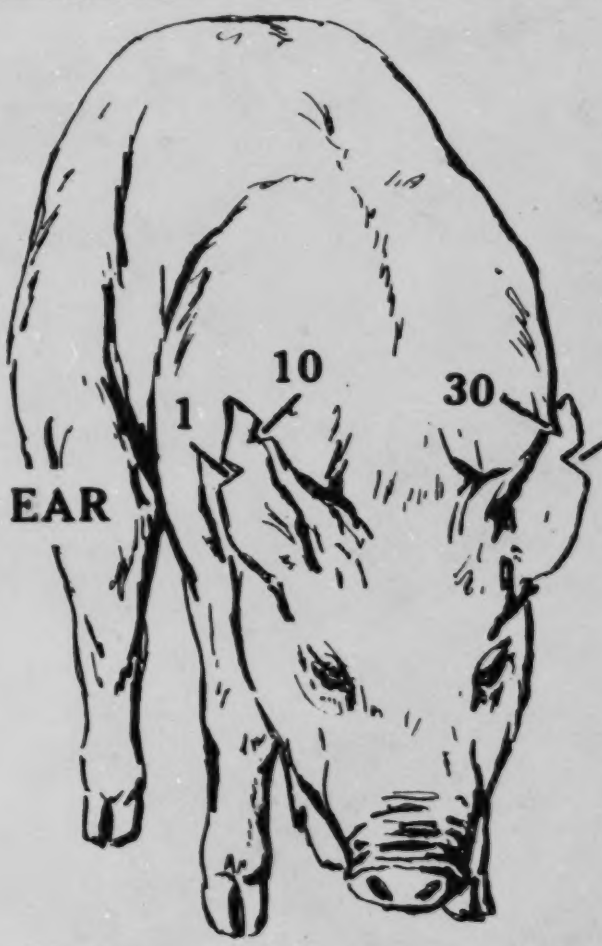
TIPPED

EAR NOTCH NUMBERING SYSTEM



EAR NOTCHERS

864



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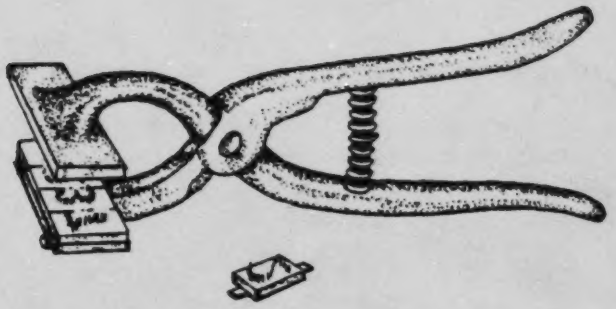
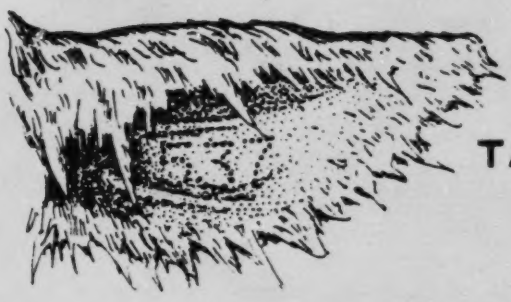
TATTOOING



TATTOOING PLIERS

TATTOO INK



TATTOO IN EAR

EAR TAGGING

METAL OR PLASTIC TAG

RUBBER TAG

Glossary of Terms:

Running Irons - Branding irons having straight characters with simple hooks. Such letters as A, M, N, W, and X usually can be made with a running iron by making the required number of applications to complete the letter.

Stamping Irons - Branding irons having pre-formed letter and number characters used for stamping the desired brand on the animal.

Denatured Alcohol - Alcohol which is unfit for drinking but useful for other purposes.

Jockey Club - An organization that handles the registration and rules and regulations of thoroughbred horses that participate in horse racing. Every thoroughbred that races in this country must be registered with the Jockey Club.

Student Activities:

1. What are the principal methods used to identify animals today?
   a.
   b.
   c.
   d.
   e.

2. What are the two general types of branding irons?
   a.
   b.

3. What is the policy in Texas for recording brands that are used for animal identification?

4. What are three methods of branding that can be done with branding irons?
   a.
   b.
   c.

5. Is there any notable difference in the procedure for horn branding and hide branding?

6. What is the greatest difficulty encountered in liquid branding?

7. What are the two ingredients that are mixed to make the fluid used in freeze branding.

   a.

   b.

8. What is a step that is suggested in the preparation of an animal before branding by the freeze or liquid branding methods?

9. Identify the following kinds of ear marks.

a.

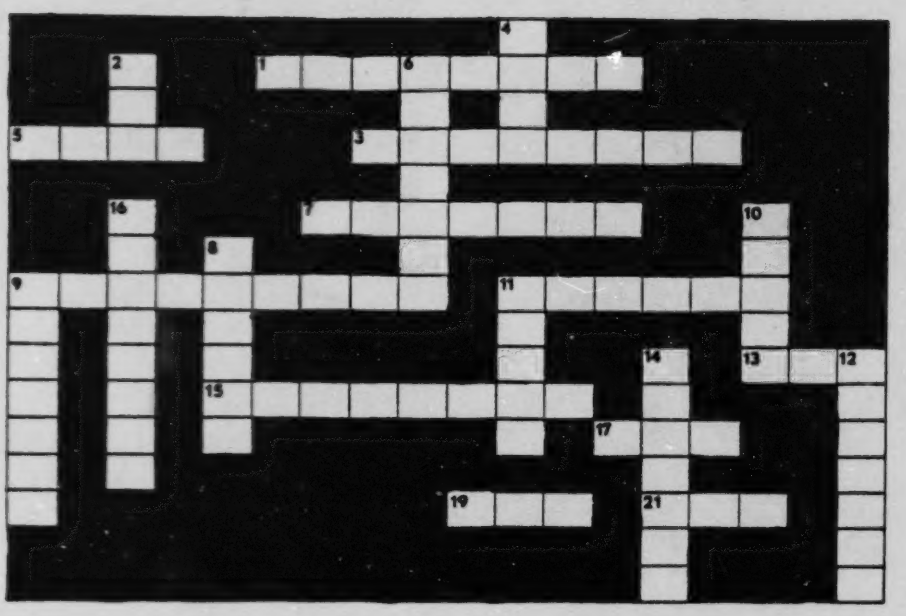
b.

c.

d.

e.

f.



10. Crossword Puzzle

Across:

1. Are secondary to and should be recorded along with the stockman's brand.
3. First used for permanently marking human criminals.
5. Breeders of purebred horned cattle could use this method of hot iron branding.
7. For best results with liquid and freeze branding, the area on the animal where the brand will be applied should be _____.
9. A permanent method of identification whereby letters or numbers are placed in the ear of cattle or inside the upper lip of horses.
11. The most recently developed method of branding.
13. _____ tattooing of horses is required by the Jockey Club.
15. A type of hot iron brand.
17. The ear tattoo gives a permanent means of identification as an indelible ____ is rubbed into the perforations.
19-21. To prepare the fluid for freeze branding denatured alcohol is poured over _____ _____.

Down:

2-16. The system of identification required by most swine breed associations.
4. State programs to eradicate bovine tuberculosis and brucellosis require positive reactors to be branded with a hot _____.
6. A method of identification about as widespread as branding.
8. Type of iron recommended for freeze branding.
9. Application of metal or plastic tags in the animal's ear for identification.
10. Hot iron branding irons can be made from copper or _____.
11. For liquid branding the iron is dipped in 1/8 to 1/4 inch of commercial branding _____ and pressed against the skin for a few seconds.
12. Most ear tags are made from this material.
14. Two general types of branding irons are "stamping" irons and "_____" irons.

11. Using the numbering system as shown in the illustration, page 5, determine the identification number of the diagram below.

12. Why are ear tags not considered a permanent identification?

13. What precautions should be observed as to placement of the tattoo number inside an animal's ear?

14. Use opportunities that may be afforded in class laboratory experiences or on the home farm to witness and gain actual experience in the various procedures of animal identification.

LIVESTOCK SKILLS

Topic 5: Docking Sheep

*Terms: All terms underlined are in the "Glossary of Terms."

I. Docking Sheep

Docking improves the general appearance of sheep, eliminates the constant threat of flies, and makes it easier for ewes to breed. Buyers prefer to purchase docked sheep.

It is usually best to dock sheep at an early age, two months or less, because there is less shock and healing is much faster; however, older sheep may be docked. The rancher should select a cool, sunny day to dock; and to eliminate excessive handling, they may dock at the same time they castrate.

There are several methods of restraining a lamb for docking. One method is for the holder, holding the lamb's right legs with their right hand and the left legs with their left hand, to stand upright while pressing the lamb's back against their body. The holder may hold the legs in the same manner while seated, or the holder may hold the lamb's legs in the same manner with the lamb's buttocks resting on a table or docking stool. The stockman who doesn't have an assistant may restrain the lamb by holding it in a standing position while exerting pressure on the lamb with their legs. The stockman and the lamb should be facing opposite directions; thus, the stockman is in the position to bend over and dock the lamb.

All instruments used in docking should be disinfected before their use. If cutting instruments are used, they should be disinfected after the docking of each lamb.

When using a method of docking that causes bleeding, the stockman should push the skin toward the lamb's body so there will be a surplus of skin to cover the stub. Usually the dock will heal faster with a skin covering.

The tails of ewe lambs are left about two inches long, while the tails of wethers may be cut four to six inches long. This makes the sexes easier to separate because they are readily distinguishable in the flock.

Transparency No. 1

II. Methods of Docking

There are several methods that may be used to successfully dock lambs, and there are advantages to each method. The method used will be determined by the stockman's preference. An explanation of several of the most popular methods follows:

A. Docking with a Knife

After the joint to be cut is located, the stockman should twist the tail a quarter turn before cutting it off with a knife. This will give a diagonal cut across the blood vessel and will increase the possibility that the blood will clot quickly. If pruning shears, which are the docking instrument preferred by some stockmen, are used, the tail should also be twisted before cutting it off.

B. Docking with the Burdizzo

When docking lambs with burdizzos, the stockman places them on the tail at the point where the tail is to be severed and closes the burdizzo. The tail is cut off inside the closed jaws of the burdizzo. After the tail is removed, the burdizzo should be held in place for a few seconds to prevent excessive bleeding.

C. Docking with the Emasculator

The emasculator, which crushes the tissue as it cuts, lessens the loss of blood; it is closed on the tail at the point where it is to be docked.

D. Docking with the Elastrator

The elastrator is an instrument that stretches special rubber bands over the lamb's tail and provides a bloodless method of docking. To dock the lamb, the stockman, leaving the band at the point where the lamb is to be docked, releases the pressure on the band and frees the elastrator. The band cuts off the supply of blood and atrophy follows. Some stockmen cut the tail off below the rubber band after it has been on the tail for nine to eleven days. Four to eight weeks, depending on the size of the lamb, are required for the lamb's tail to fall off below the rubber band.

E. Docking with a Hot Iron

The hot iron used for docking lambs is usually shaped like a chisel. After the iron is heated to a dull red color, the stockman, to protect the lamb's buttocks, places its tail through a hole in a board and severs the tail with the hot iron. This method of docking reduces the loss of blood and lessens the danger of infection, but requires longer to heal.

III. Treatment

There are several antiseptic solutions used to treat the dock; but the stockman should not treat the dock with a screw worm smear, as this causes stiffness in some lambs.

DOCKING LAMBS

ASII-XIII-68

RESTRAINT

874

SLIPPING SKIN FORWARD

REMOVAL USING EMASCULATOR

875

TM-1

LIVESTOCK SKILLS

Topic 6: Injection Procedures

*Terms: All terms underlined are included in the "Glossary of Terms."

I. Importance of Vaccines, Bacterins, and Serums

To understand the importance and value of vaccines, the livestock producer must be acquainted with the organisms that cause diseases.

When an animal becomes sick because of interference with proper body and cell functions, microbes, often called microorganisms, invade the body and overcome its natural defenses. Pathogenic microbes, which cause disease, vary in size and are found in large numbers. It has been estimated that there are more microorganisms in a small amount of soil than there are people on the earth. However, most of the microorganisms are helpful to plants and animals.

After the microbes enter the animal's body, they consume body cells and fluids and cause a poison, called toxins, to develop in the body. The increase in the number of microbes in the body varies with the kind of disease, the strength (virulence), and the animal's resistance. Microbes also are able to multiply and increase so rapidly because of their high rate of metabolism, which allows them to consume many times their size in the consumption of food, body cells, and fluid.

As the microbes enter the body, several kinds of body forces combine in an attempt to kill the invaders and neutralize the toxins. These body forces, called antibodies, are made from body cells and tissues. Their job is to kill the microbes. The animal is immune to a disease from which it has recovered if its cells continue to make antibodies. Scientists reasoned that if antibodies protect an animal against disease, the injection of antibodies into a susceptible animal would give this animal immunity. This idea has saved millions of animals, as well as human beings.

Vaccines, bacterins, and serums are used to produce immunity. Vaccines, which are made from living germs, give the animal a mild attack of the disease; antibodies are produced and immunity is obtained. Bacterins, which are smaller to vaccines, are made from dead organisms and are stored in oil or water

that contains the same amount of salt as the body fluids. Bacterins also cause the body to make antibodies. Serums are produced when plasma and fibrinogen have been removed from blood. Serums give only temporary immunity to the animal because their injection into the body does not cause the body forces in the animal to make antibodies.

Different microbes prefer different kinds of environment; some live only in the presence of air, and others can live without air. Under suitable conditions microbes form spores. These spores can live several years without food under adverse conditions, such as extreme heat and cold. Many diseases are perpetuated by spores. Most microbes multiply by simple division; when reaching a certain size, they divide in halves.

Another form of microscopic life which causes diseases in livestock is called bacteria, a one-celled plant. The three kinds of bacteria are Bacilli, Cocci, and Spirila.

Viruses also are responsible for many livestock diseases; many of the diseases caused by viruses can be controlled by vaccines.

II. Injection Procedures

A. Factors to Consider in Handling Biological Products

Transparency No. 1

To acquire better immunization in livestock, the stockman should consider the following factors for handling biological products:

1. Biological products should be protected from heat and light, and they should be kept in a refrigerator at 35° to 45°F. Vaccines should not be frozen.

2. If vacuum-dried vaccines are being used, they should be used immediately after being mixed with the sterile diluent.

3. Animals should be properly restrained.

4. The biological product should be used when first opened. Unused vaccine may become contaminated.

5. Sterilized instruments should be used.

6. Uniform suspension may be obtained by shaking the vaccine.

7. The recommended dosage should be given.

8. No attempt should be made to immunize diseased or unhealthy animals.

9. Instructions should be read carefully.

Antibiotics and other drugs, used as injections for disease control, are handled and stored by most livestock producers. Federal regulations require licensed manufacturers of all veterinary products to label the container or supply the buyer of the products with information on the proper methods of handling and storing the products. These instructions should be read and followed carefully.

B. Kinds of Injections

There are several kinds of injections that may be used to prevent disease and produce immunity in animals. The livestock producer should be familiar with the different kinds of injections and the terminology used to describe each.

Transparencies No. 2 and 3

1. Paraexternal Methods of Injections--Any method other than in the intestinal tract.

2. Cutaneous--The material is applied to the skin or rubbed into the skin.

3. Intracutaneous or Intradermal--Injected into the skin.

4. Subcutaneous--Injected just under the skin.

5. Intravenous--Injected into a vein when fast action is wanted.

6. Intramuscular--Injection is made into large muscles. Muscles in the neck and thigh are commonly used.

7. Intracardial--Injected directly into the heart.

8. Intrathoracis--Injected into the thorax. Not commonly used.

9. Intraocular--Under the eyelid, into the cornea, or into the anterior chamber.

10. Epidural--Directly into the spinal canal.

11. Intropulmonary--Injected into a lung.

12. Inhalation--Vapor or dust is inhaled.

13. Oral--By mouth or injected through a stomach tube.

14. Rectal (Enema)--Injected into the rectum.

15. Intramammary--Injected into the mammary gland.

16. Syringe--Instrument used to make injections, consisting of plunger, barrel, and various types and sizes of needles.

17. Stomach Tube--Tube to pass materials directly into stomach. May be inserted through mouth or nostril.

The injection used to prevent disease or to induce immunity in animals or poultry depends on the kind and amount of solution used and the animal involved. Most injection materials will be measured in cubic centimeters, commonly referred to as "cc's."

The temperature of materials to be injected and the syringes and needles should be near body temperature, but never higher. Some injections such as serums may be given at body temperature or at a colder temperature.

C. Some Instruments Used for Injections

Transparencies No. 4 and 5

Several different types of syringes are available, and the size of syringes vary from those that hold a few cc's to those that will hold as much as 50 cc's. Syringes are made from metal, plastic, or glass.

Hypodermic needles are of two kinds, those that are used once and disposed of after use and those that may be sterilized and used again. Hypodermic needles are also available in several different sizes; the size is determined by the gauge and the length of the needle. The smaller the gauge, the larger the needle will be. The length of a hypodermic needle is specified in inches.

D. Preparing for the Injection

Before making an injection, a stockman should make certain preparations. A sharp needle of the proper size, which is determined by the method of injection to be applied, should be selected. Instruments should be sterilized before being used. They may be sterilized by boiling them in water for fifteen minutes or by

soaking them in a 70% alcohol solution. If injections are made in several animals, the needle or instrument used for the injection should be sterilized before each injection.

To eliminate the possibility of forcing unwanted micro-organisms in the animal's body, the stockman should clip or shave the hair and clean the area where the injection is to be made with an antiseptic solution.

Before filling a syringe for an injection, the stockman should carefully read the instructions that come with the vaccine. The syringe is filled by pulling the plunger out to allow air to fill the syringe, then the needle is pushed through the disinfected stopper. The bottle is inverted and the air forced from the syringe by depressing the plunger. The plunger is slowly pulled out until the barrel is filled to the desired level. The needle is removed from the bottle while the syringe is held with the needle up; in this way, air bubbles are forced from the barrel. Another method of filling the syringe that might be used if more than one injection is to be given is to leave the needle in the stopper of the bottle and attach another sterile needle to the syringe before each injection.

E. How to Make Injections Properly

Transparencies No. 6 and 7

Injections of various medicinal agents are commonly administered by stockmen. Such injections are a convenient and accurate means of treating sick animals or administering vaccines, serums, and bacterins.

1. Subcutaneous Injections (Sub Q)

   Subcutaneous injections may be made in any area over which the skin fits loosely such as the neck, chest wall, "armpit" or flank. A small area is cleansed with alcohol and the needle inserted through the skin and the syringe contents discharged. A fold of skin may be picked up to facilitate entry of the needle. Following the injection, the area may be massaged to facilitate distribution.

2. Intramuscular Injection (IM)

   Intramuscular injections should be made deeply into a large muscle (thigh, shoulder or neck). Cleanse an area as outlined above and insert the needle deeply into the muscle. Use a needle at least 3/4" in length for cattle, sheep, and swine.

3. Intraperitoneal Injection (IP)

Used mainly for the administration of large quantities of fluid such as Calcium Gluconate, Dextrose, Triple Sulfa, etc., for cattle. (1) Use a long needle--16 gauge x 2" or 14 gauge x 3". (2) Warm the solution to body temperature prior to administration. Insert the needle into the right flank at a point in the center of the triangle formed by the loin, last rib, and a line from the top of the last rib to the hip bone. Use sterile precautions.

4. Intrarumen Injection (IR)

Used to administer medication promptly in bloat. Always insert needle through the LEFT flank. Use 14 gauge x 3" needle. Proper position of needle is noted by return through the needle of gas or liquid from the stomach.

5. Intradermal (ID)

Injection is made with a 20-26 gauge needle into the skin. Proof of intradermal injection is a blister raising consisting of ingredient injected. Hair should be shaved previous to injection.

6. Intramammary (IMM)

The infusion can be accomplished by disinfecting the teat, depressing the teat to open the sphincter muscle, inserting the sterile canula, and forcing the medication into the teat canal from the syringe or tube. Disinfect the teat after infusion.

7. Intravenous (IV)

This injection is done into a vein--most commonly the jugular vein. This vein is located in a groove that is located from the back point of the jaw bone and angles to the point of the shoulder on either side of the neck. Applying pressure by tourniquet or thumb pressure cutting off the blood flow, and this enlarges the vein to visible size. Disinfect and insert needle through the skin into the vein. Once into the vein, the needle should be directed upward towards the head inside the vein. Always check for blood flow before attaching the intravenous tube and allowing medication to enter blood stream. The flow of product should be slow.

FACTORS TO CONSIDER IN HANDLING BIOLOGICAL PRODUCTS

1. BIOLOGICAL PRODUCTS SHOULD BE PROTECTED FROM HEAT AND LIGHT, KEPT REFRIGERATED AT 35° TO 45° F., AND SHOULD NOT BE FROZEN.

2. VACUUM-DRIED VACCINES SHOULD BE USED IMMEDIATELY.

3. ANIMALS SHOULD BE PROPERLY RESTRAINED.

4. THE BIOLOGICAL PRODUCT SHOULD BE USED WHEN OPENED TO PREVENT CONTAMINATION.

5. STERILIZED INSTRUMENTS SHOULD BE USED.

6. UNIFORM SUSPENSION MAY BE OBTAINED BY SHAKING THE VACCINE.

7. THE RECOMMENDED DOSAGE SHOULD BE GIVEN.

8. NO ATTEMPT SHOULD BE MADE TO IMMUNIZE DISEASED OR UNHEALTHY ANIMALS.

9. INSTRUCTIONS SHOULD BE READ CAREFULLY.

KINDS OF INJECTIONS

1. PARAEXTERAL METHODS OF INJECTIONS - ANY METHOD OTHER THAN IN THE INTESTINAL TRACT.

2. CUTANEOUS - THE MATERIAL IS APPLIED TO THE SKIN OR RUBBED INTO THE SKIN.

3. INTRACUTANEOUS OR INTRADERMAL - INJECTED INTO THE SKIN

4. SUBCUTANEOUS - INJECTED JUST UNDER THE SKIN.

5. INTRAVENOUS - INJECTED INTO A VEIN WHEN FAST ACTION IS WANTED.

6. INTRAMUSCULAR - INJECTION IS MADE INTO LARGE MUSCLES. MUSCLES IN THE NECK AND THIGH ARE COMMONLY USED.

7. INTRACARDIAL - INJECTED DIRECTLY INTO THE HEART.

8. INTRATHORACIS - INJECTED INTO THE THORAX. NOT COMMONLY USED.

9. INTRAOCULAR - UNDER THE EYELID, INTO THE CORNEA, OR INTO THE ANTERIOR CHAMBER.

10. EPIDURAL - DIRECTLY INTO THE SPINAL CANAL.

11. INTRAPULMONARY - INJECTED INTO A LUNG.

12. INHALATION - VAPOR OR DUST IS INHALED.

13. ORAL - BY MOUTH OR INJECTED THROUGH A STOMACH TUBE.

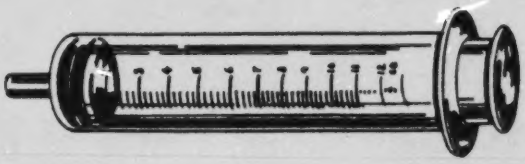
14. RECTAL (ENEMA) - INJECTED INTO THE RECTUM.

15. INTRAMAMMARY - INJECTED INTO MAMMARY GLAND.

16. SYRINGE - INSTRUMENT USED TO MAKE INJECTIONS, CONSISTING OF PLUNGER, BARREL, AND VARIOUS TYPES AND SIZES OF NEEDLES.

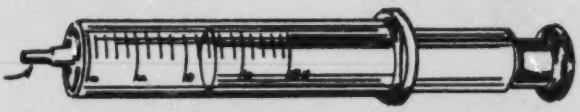
17. STOMACH TUBE - TUBE TO PASS MATERIALS DIRECTLY INTO THE STOMACH. MAY BE INSERTED THROUGH THE MOUTH OR NOSTRIL.

VACCINATING EQUIPMENT

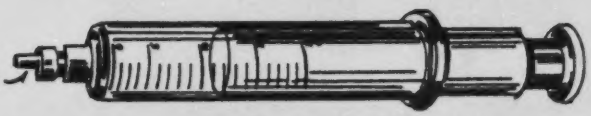


DISPOSABLE PLASTIC SYRINGE

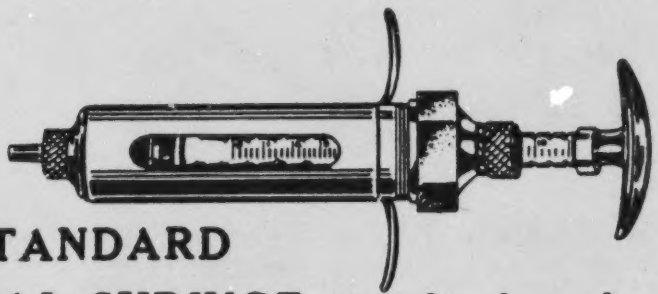
plain or
metal tip



luer
lock tip

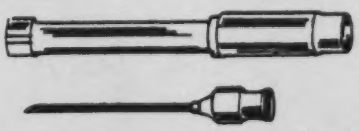


REUSABLE GLASS OR NYLON SYRINGES



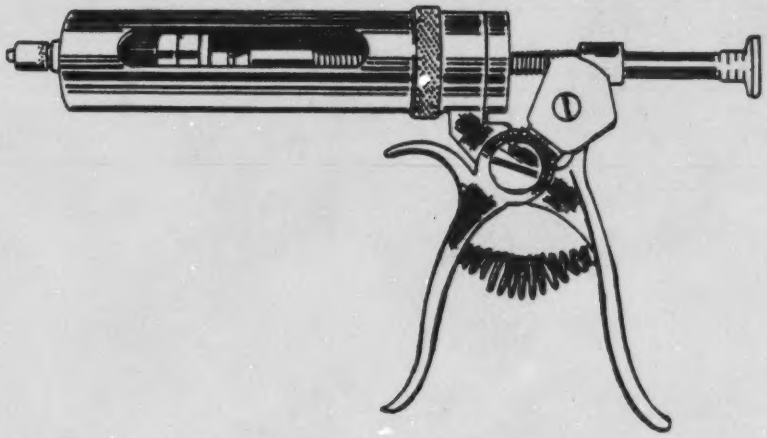
STANDARD
METAL SYRINGE (with glass barrel)

REUSABLE
STAINLESS NEEDLE

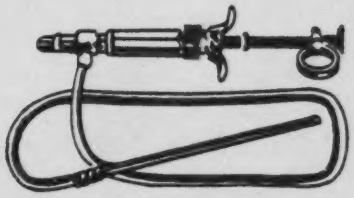


DISPOSABLE
STERILE NEEDLE

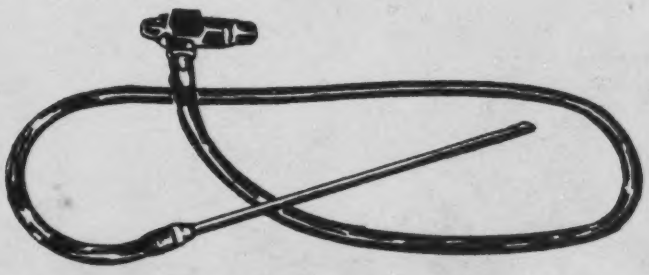
VACCINATING EQUIPMENT



AUTOMATIC REPEAT (PISTOL GRIP) SYRINGE

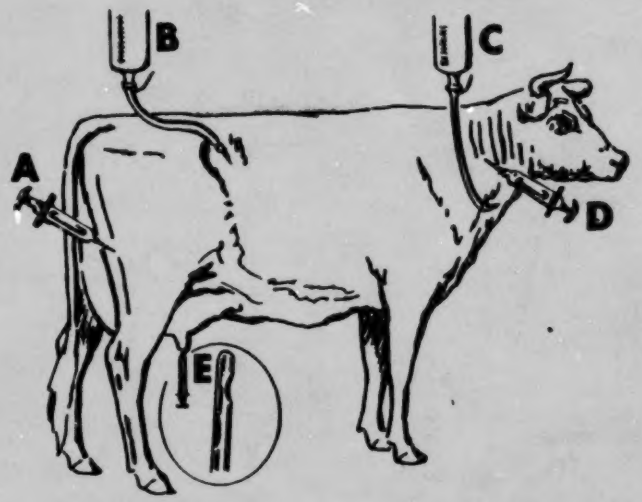


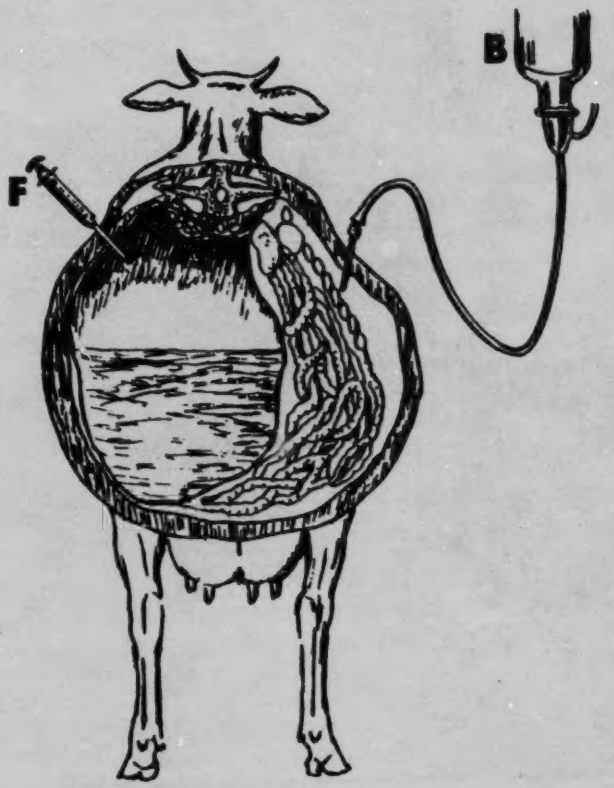
SELF-FILLING AUTOMATIC SYRINGE (PUMP TYPE)



SYRINGE FILLER ATTACHMENT

LOCATIONS AND TYPES OF HYPODERMIC INJECTIONS FOR CATTLE



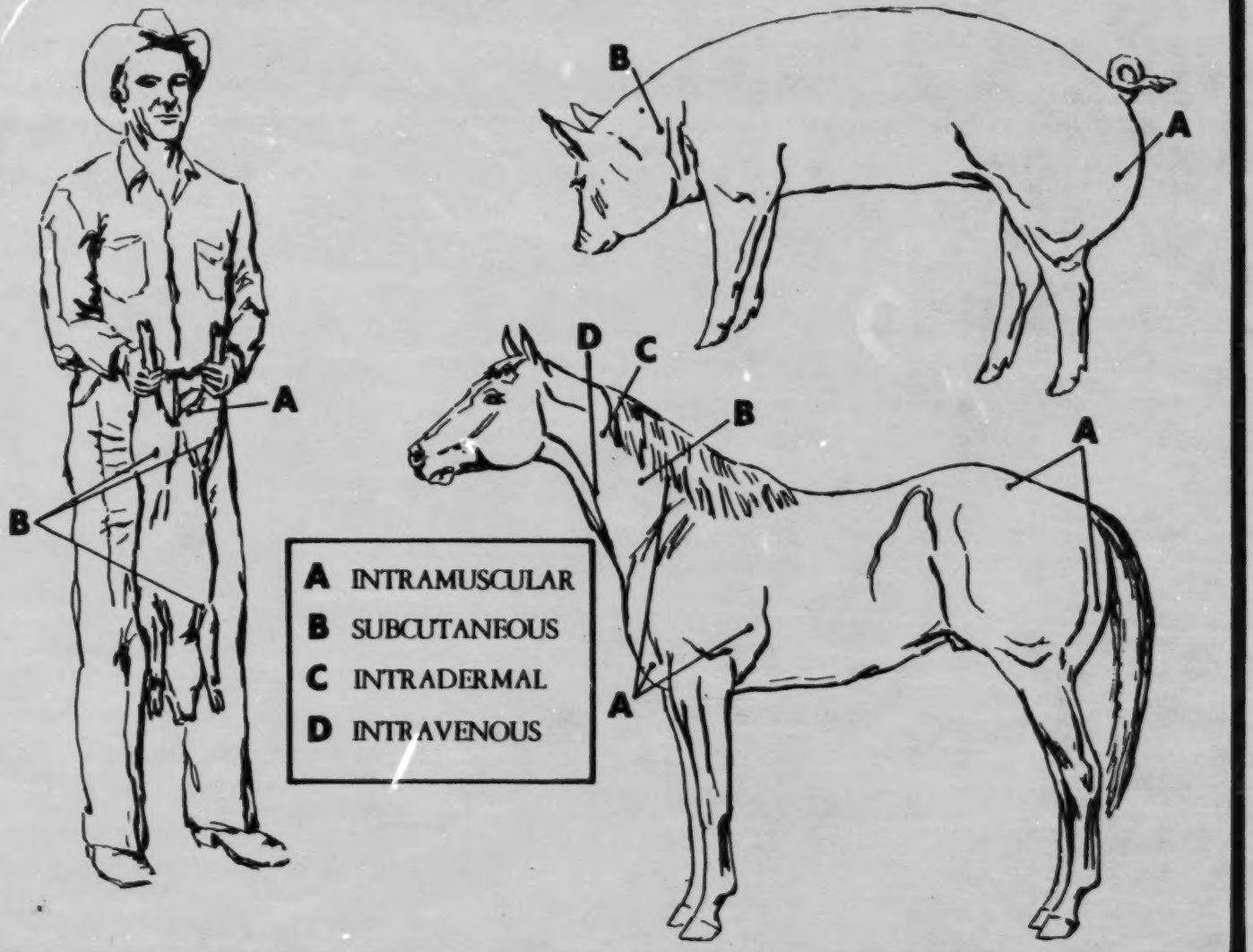


A INTRAMUSCULAR
B INTRAPERITONEAL
C INTRAVENOUS
D SUBCUTANEOUS
E INTRAMAMMARY
F INTRARUMENAL

AgII-XIII-80

TM-6

LOCATIONS AND TYPES OF HYPODERMIC INJECTIONS FOR HORSES AND SWINE



TM-7

AgII-XIII-81

889

890

Glossary of Terms:

Bacterins - Bacterial vaccines.

Metabolism - The sum of all the physical and chemical processes by which living organized substance is produced and maintained.

Pathogenic Microbes - Minute living forms of life which are capable of causing disease in animals.

Serums - Fluid portion of blood from animals that have been inoculated with bacteria or their toxins. Such serum, when introduced into the body, produces passive immunization by virtue of the antibodies which it contains.

Toxins - Poisonous substances of microbic, vegetable, or animal origin.

Vaccines - Suspensions of attenuated or killed microorganisms administered hypodermically for the prevention or treatment of infectious diseases.

Viruses - Any living submicroscopic agent causing infectious disease.

Suggested Student Activities:

1. Distinguish between vaccines, bacterins, and serums in their abilities to produce immunity to diseases.

2 What are the three kinds of disease producing organisms responsible for livestock disease?

a.

b.

3. List three practices that should be closely observed for handling biological products for livestock immunization programs.

   a.

   b.

   c.

4. What are the two kinds of injections most frequently used in livestock immunization programs?

   a.

   b.

5. List the five types of syringes that are mentioned as being available for making injections.

   a.

   b.

   c.

   d.

   e.

6. What form of measurement is used for measuring most injection materials?

7. How is the size of a hypodermic needle determined?

8. What are some steps that should be observed before making an injection?

   a.

   b.

   c.

   d.

9. Explain how to fill a syringe properly.

10. List the locations and types of hypodermic injections shown for administering vaccines, serums, and bacterins for cattle.

    a.

    b.

    c.

    d.

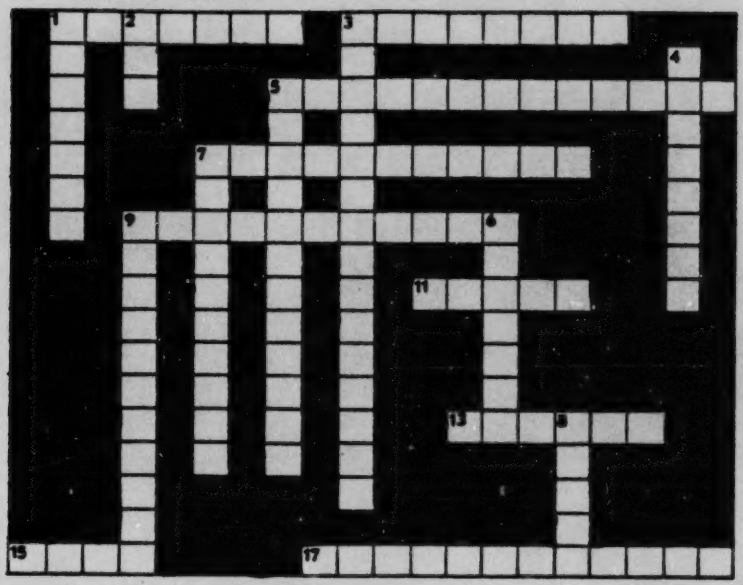
    e.

    f.

11. List the location and types of hypodermic injections shown for administering vaccines, serums, and bacterins for horses and swine.

Horses	Swine
a.	a.
b.	b.
c.	
d.	

12. Use opportunities that may be afforded in class laboratory experiences or on the home farm to witness and gain actual experience in the various procedures for administering vaccines, serums, and bacterins.



13. Crossword Puzzle

Across:

1. A suspension made from the disease producing organism which can be administered hypodermically for the prevention or treatment of infectious diseases.
3. Condition present in an animal's body as a result of the antibodies produced following vaccination.
5. Injection made into the large muscles of the body.
7. Injection made under the eyelid or into the cornea.
9. Injection made into a vein.
11. Produces passive immunity when introduced into an animal's body.
13. Injection by enema into the rectum.
15. By mouth or injected through a stomach tube.
17. Injection made just under the skin.

Down:

1. Living submicroscopic agents causing infectious disease.
2. Cubic centimeters (abbr.).
3. Injection used mainly for the administration of larger quantities of fluid such as Calcium Gluconate for cattle.
4. Bacterial vaccine.
5. Injection made into the mammary gland.
6. Instrument used for making injections.
7. Injection used to administer medication promptly in bloat.
8. Poisonous substance of microbic, vegetable, or animal origin.
9. Injection made into the skin.

LIVESTOCK SELECTION
(OPTION UNIT)

Instructor's Guide

1. This is an option unit. If you cover livestock selection elsewhere in your four-year instructional program one of the following production units may be considered as an alternative. Complete production instructional units are available as follows:

   Beef Production:

   "Cow-Calf Management Guide -- Cattleman's Library"
   Dean Frischknecht, Extension Animal Science
   Animal Science Department
   Oregon State University
   Corvallis, Oregon 97331

   Sheep Production:

   "The Sheepman's Production Handbook"
   Abegg Printing
   Denver, Colorado

   Swine Production:

   "Pork Producer's Handbook"
   Dean Frischknecht, Extension Animal Science
   Animal Science Department
   Oregon State University
   Corvallis, Oregon 97331

2. This unit is designed to provide students with the basic concepts of livestock selection through live animal judging and grading and carcass evaluation. A balance of conformation judging and production performance evaluation is essential for success in selecting animals.

3. This unit merely provides background material for the selection process and must be complemented with lab sessions that include live animals and carcass evaluation.

4. Other supplementary material such as practice judging slides will greatly enhance the effectiveness of this unit. Your own judging slides are most effective because you can personalize the instruction; however if you do not have your own judging slides an excellent set may be obtained from the following address:

   Vocational Education Productions
   Cal Poly State University
   San Luis Obispo, California 93407

5. The materials for this unit were selected from curriculum developed by Texas A & M University.

6. A unit on Poultry Judging and Poultry and Egg Grading is included as an additional optional unit for those teachers that emphasize poultry in their curriculum.

Objectives

Upon completion of this unit, the student will be able to:

1. Place classes of cattle, sheep, swine, and dairy animals by use of basic judging skills.
2. Describe livestock placings in common descriptive terms of judging terminology.
3. Identify market classes of livestock.
4. Recognize common breeds of livestock.
5. Identify slaughter grades of livestock.
6. Identify wholesale cuts of meat.
7. Judge carcass conformation and quality.
8. Identify carcass (yield) grades of livestock.
9. Identify breeding classes of livestock.
10. Judge quality of carcasses of cattle, sheep, and swine.
11. Judge poultry.
12. Grade poultry and eggs.

Student Activities

1. Read objectives.
2. Read infromation sheets.
3. View transparencies and listen to instructor explanation of material.
4. Judge practice classes of live animals.
5. Give oral reasons for placings of live animal classes.
6. Judge slides to gain experience in placing and giving reason.
7. Take a field trip to a meat processing plant and/or meat market for carcass evaluation.
8. Judge slides to improve carcass judging ability.
9. Visit local retail meat market to further sharpen skills in identification of meat cuts and carcass evaluation.
10. Judge and grade poultry and eggs.

Teaching Aids

1. Objective sheets.
2. Information sheets.
3. List of terms and objectives.
4. Transparency Masters.
5. Slide sets for judging and carcass evaluation.

References

1. Livestock and Poultry Judging and Evaluation, Vocational Instructional Services, Texas A & M University, College Station, Texas 77843.

2. Livestock Evaluation Slides, Vocational Education Productions, California Polytechnic State University, San Luis Obispo, California 93407.

3. Oregon Extension 4-H Materials on Beef, Sheep, Swine, Dairy, Poultry and Rabbits. Available at your local Oregon State University Extension Office.

4. Resource Unit on Livestock Selection, Department of Agricultural Education, The University of Arizona, Tuscon Arizona.

5. Judging Livestock, VAS 1019A, Vocational Agriculture Services, University of Illinois, Urbana, Illinois.

6. Livestock Judging Guide, Oklahoma Extension Circular 709.

ANIMAL SCIENCE

Topic 1: Live Animal Judging and Grading

*Terms: All terms underlined are in the "Glossary of Terms".

Note: Since the selection of livestock, based on conformation, was one of the areas discussed in the Oregon Agriculture I Guide, these materials do not include the same information. It is also assumed the V.A. II students have developed a mental image of the proper conformation of animals and are familiar with the wholesale cuts of meat and their location on the carcass.

1. Judging

The ability to judge livestock is a skill that the livestock producer is constantly using and one that is essential for continuous, successful production. Livestock judging is an art or science that can be acquired by the individual through study and practice.

The ability to recognize high quality and efficient animals: (1) will help to increase the students' interest in animals and agriculture; (2) will help the student develop an appreciation of the importance of livestock production in the total food production of the nation's economy; (3) will provide a knowledge of animals and meat, which is necessary for animal improvement and an improvement in production efficiency; and (4) will teach the student to make accurate observations.

The information contained in this topic pertains to the visual appraisal of animals. The student or livestock producer should keep in mind that visual appraisal is only an estimate. A more accurate appraisal can be made when production records are available.

2. A System of Judging

In order to become a good livestock judge, the student should follow an orderly system of observing the animals in the class. Some authorities recommend a system composed of four steps; the student observes a certain part of the animal in each step.

Using this system, the student in the first three steps would observe the animal from a distance of fifteen to twenty feet; and in step 4, the contact step, he/she moves in close and feels of the animal, if the animals are allowed to be touched by the contest rules.

The following factors to consider in each step pertain to judging steers. The same system can be used in judging other classes of livestock.

Transparency No. 1

The animals should be observed from the side in step 1. Top and bottom lines, levelness of rump, muscling in the arm and forearm, trimmers in middle, length and depth of body, and

length of leg are some of the factors that should be considered in this step.

Steer No. 1 in the transparency is a correctly finished steer with moderate length and depth of body. It has a long, full rump and is muscular in the arm and forearm. It is trim in the brisket, flank, cod, and middle.

Steer No. 2 is an overfinished steer with average muscling. It is too deep in its body, and its legs are too short. This steer is wasty in the middle and has a heavy, wasty brisket.

Steer No. 3 is underfinished and is long legged and shallow bodied. Its rump is drooping, and it lacks overall muscling.

Transparency No. 2

In step 2 the animal is observed from the rear; the animal's width, depth of twist, depth of round, heart girth, turn over the top, and uniformness of width in the back, loin, and rump are noted.

The student will notice that Steer No. 1 has the width at the pins and is long from the pins to its twist. It has a uniformly wide, thick back with a correct turn (⌒) to the top.

Steer No. 2 tapers from the top of the back to the twist and lacks length of round. It has a wide, flat, square-cornered (⌐¬) top, which indicates excessive fat over the crops and along the edges of the loin.

Steer No. 3 has a narrow, flat, tapered round and is narrow at the pins. It has a prominent tailhead and hooks and has a triangular-shaped (∧) back.

Transparency No. 3

In step 3 the animal is observed from the front. Characteristics to observe are the width between the legs, muscling in the shoulders, the animal's head, and its substance and soundness.

As is illustrated in the transparency, Steer No. 1 is a heavy-boned steer with wide front legs. It is trim in the brisket but has enough fullness to indicate quality.

Steer No. 2 lacks width between the legs and has only average bone development. The excessively heavy, full brisket is very much in evidence.

The poorly muscled Steer, No. 3, is narrow between the legs, light in bone development, and lacks enough fullness of brisket to grade above USDA Good.

In step 4, the student should determine whether their judgment is correct after they have completed the first three steps. As the student feels of the animal, they should determine the smoothness and amount of covering possessed by the animal.

A beef animal starts putting finish on in the area of the forerib first. If the animal is properly finished, the student should be able to feel finish from the forerib to the rump. The finish should start at the animal's shoulders. Using one hand, the student feels of the animal's crops, back, fore and hind ribs, loin, and rump.

After feeling of the animal, the student should know the degree of finish, evenness of finish, and firmness of covering. The above procedure should be followed each time a student judges.

Rules in Judging

Judging is sound reasoning, and a student should not follow hunches or try to "play" the official judge's decision. Since the student will usually be judging with a group, they should disregard any remarks that may be made by other participants.

1. The following points should be considered before placing the class.
   a. For what purpose is the class being judged?
   b. What are the outstanding characteristics which make the animal valuable for that purpose?
   c. How does the animal compare with the ideal?
   d. In what order would you select the animals if you were buying them?
2. Each class should be judged individually and according to its purpose and not by the standards of a previous class. Each animal should be observed carefully and objectively; the student should see the animals as they are and not as he would like to see them.
3. The class should be analyzed. If possible, the animals should be divided into groups: a top and a bottom; a top pair and a bottom pair; a top and three bottoms; or three tops and a bottom.
4. The class should be placed through a process of elimination; and brief, accurate notations should be made.
5. The first impression is nearly always right.
6. If the student becomes rattled, they should stop, back off from the class, and think. They should ask themselves the questions a, b, c, and d under rule number 2; and
7. The student should go over the class again to see if they used sound reasoning in making the judgment.

3. Factors to Consider in Judging Livestock

Beef Cattle

Beef cattle are listed first because they are the easiest class of animals to judge. They can be trained to stand and lead; they have greater size, and their hair does not usually mask their shape.

Prior to starting the judging excersises, the student should learn the more common descriptive cattle terms and understand the meaning of each. These terms are listed on the following page.

Marketing Cattle Terms

1. "More beefiness" or "muscling" - in the regions of the highpriced cuts.
2. "Over finished" - over 1 inch of fat over the 12th rib as indicated by a wasty brisket, full cod, full near flank, and patchy tail setting.
3. "More correct finish" - over the back and ribs (.5 to .8 inch at the 12th rib is correct).
4. "Higher" or "lower" - grading.
5. "More uniform in finish" - a higher or lower dressing percentage.
6. "Wasty-middled" - bulging middle.
7. Dress "higher" or "lower" - a higher or lower dressing percentage.
8. "Will yield" - a higher percentage of preferred steak and roast cuts (loin, rib, round, rump, and chuck.)
9. "Will hang up" - a meatier, more desirable carcass; a meatier carcass and less fat trim; a higher valued carcass.

Market and Breeding Cattle Terms

1. Terms that describe muscling are a "Thicker, more muscular round"; "Thicker through the middle and lower round"; "Thicker through the stifle"; "More correct turn of top"; "Wider loin"; "More muscular shoulder"; "stands with more width in front and behind"; "walks with more width between front and hind legs"; and "Heavier bone".
2. "Stronger topped" - a stronger back.
3. "Squarer-rumped" - full in the rump.
4. "Longer rump" - longer from hooks to pins.
5. "More spring of rib and deeper heart girth" - indicates more constitution.
6. "Smoother-fleshed" - an animal with smooth fleshing qualities.
7. "Beefier heavier quartered" - more lean and muscle in the hind quarters.
8. Terms used to describe quality and refinement are "finer hair coat", "thinner hide", and "more refined head".
9. "More correct in depth of body" - animal with ideal depth.
10. Terms that describe sex character are "a well-developed udder" (female) and "normal testicle development" (male).

The student should use the Fat Cattle Judging Blank the first few times they judge steers or fat animals. The card will prevent them from overlooking some of the important factors that should be considered.

FAT CATTLE JUDGING BLANK

	1	2	3	4
Weight				
General Appearance				
Type, General outline broad, deep; compact, blocky, low-set				
Size for age. Large, early-maturing				
Symmetry. Straight top and bottom lines; not paunchy, uniform in width; smooth, stylish				
Conformation				
Head - not too large or too small for size of body; well carried, short face; wide muzzle; broad forehead; medium-sized ears				
Neck - short, thick; blending smoothly with the shoulder; tapering evenly and uniformly from shoulder to head; light crest and dewlap				
Shoulder vein - full, plump, smooth				
Shoulder - smooth, compact				
Brisket - wide, rounded, neat and trim				
Chest and heart girth - wide, full, and deep; foreflank full				
Crops - full, thick; even with the sides of the shoulders				
Back - straight, short, broad, uniform in width				
Loin - broad, level, thick				
Ribs - Widely arched, long				
Flanks - low full				
Hooks - smooth				
Rump - broad, long, level, straight, square; smooth tailhead				
Thighs or rounds - deep, full, thick, broad, bulging				
Twist - full, deep, low				
Legs - short, straight, set squarely, wide apart; fine shank, full arm				
Condition				
Covering - fat, finished; smooth, uniformly covered				
Shoulder vain - full, plump				
Brisket - plump				
Shoulders, crops, back, ribs, loin, rump, and hooks - deeply and thickly covered				
Flanks - full				
Pinbones and tailhead - thickly covered				
Thighs and twist - full, thick and plump				
Quality				
Features - refined head, neck, ears; smoothly made				
Hair - fine, soft, silky				
Skin - loose, pliable, mellow, thin to medium thickness; no excess throat or dewlap				
Bone - clean, smooth, medium sized; small horn or neat poll; slim tail; shoulder blades, hooks and tailhead not prominent				
Flesh - smooth, mellow yet firm elastic flesh; free from ties, rolls, and patchiness				
FINAL PLACING				

STEERS AND SLAUGHTER ANIMALS - Muscling, finish, and dressing percentage are the three major factors to consider in judging steers. These factors will determine the market value of the animal. Additional factors - growth rate, age, quality, correct set of legs and feet, and a desirable head shape - should also be considered if all animals in the class are equal in muscling and finish.

Muscling - in an animal is indicated by its conformation. To contribute to beef production, the animal's conformation must increase production efficiency and/or improve the yield and/or quality of meat.

Finish - a major factor affecting carcass yields of retail cuts, meat quality, and dressing percentage, is referred to as fatness or condition. Fat, especially marbling, contributes to the juciness, flavor, and palatability of the meat; external fat covering affects an animal's conformation, and an excessive amount lowers the market value of the animal.

The dressing percentage is affected by the amount of fill, degree of fatness, and the weight of "dress off" items (hide, head, and shanks). Hence, a trim middle, light hide, and the amount of finish are the major factors influencing dressing percentage. A high dressing percentage due to excessive finish is not advantageous.

A slaughter animal which is muscular and properly finished can yield a carcass worth $50.00 more than an overfinished, average muscled animal of the same height.

BREEDING BEEF ANIMALS - Beef breeding cattle are very similar to fat steers in general appearance, conformation, and quality; however, breed type, sex characteristics, and temperament, substance, and feet, legs, and action are additional factors that should be considered by the student judging breeding classes.

Breed Type is charaterized by color patterns and other characteristics which distinguish one breed from another.

Sex Characteristics and Temperament are evident in a bull by his overall masculinity, heavy shoulders, thick crest on the top of the neck, hair color, and his boldness and aggressiveness: A cow with the proper sex characteristics and temperament is gentle, calm and more refined, and has a clean dewlap and brisket. The cow's hair is generally slick and shiny.

Substance is indicated by ample bone and a heavy muscle.

The feet, legs, and action of a breeding animal is very important. The breeding animal's feet should be normal, and it should stand on straight legs. Their action should be free and easy.

SHEEP - The same factors (muscling, finish, and dressing percentage), considered in judging steers are considered in judging lambs.

Market Lamb Terms

1. Indications of muscling are "plumper legs", "wider loin", "thicker top", wider over the rack", "more muscular shoul-

der", and "stands wider in front and behind".

2. Terms used to describe finish are "more uniformly finished", "firmer finish", "more correctly finished (.2 to .3 inch preferred)", and "more finish over the top and ribs".
3. "Longer rump" - longer from hocks to pins.
4. "Squarer dock" - a full, wide dock.
5. "Deeper twist" - more distance from pins to twist.
6. "Trimmer middle" - no excessive bulging of the stomach.
7. "Lighter" or "heavier" pelt - skin of a sheep and including the wool.
8. "Stronger top" - a stronger back.

Breeding Sheep Terms

1. "More size and scale" - a larger animal.
2. Terms descriptive of the feet and legs are "heavier, more rugged bone"; "shorter, stronger pasterns"; and "straighter legged".
3. Terms describing muscling are "plumper leg", "wider loin", "thicker top", "stands and walks wider on hind and front legs".
4. "More Hampshire, Rambouillet, Suffolk, etc., breed character about the head".
5. "More feminine head" and "more masculine head".
6. "Deeper chest" - more depth from top of shoulder to chest floor.
7. "Wider spring of the rib" - more spring of the ribs.
8. "Stronger top" - a stronger back.
9. "Longer, leveler rump" - more length from hocks to pins and very level in the rump area.
10. "Squarer dock" - full, wide, and deep in the dock.

Fleece Terms

1. "Longer staple" - wool fibers are longer.
2. "More uniform in staple length" - more fibers of the same length.
3. "Finer fleece" - finer wool.
4. "More uniformity of fineness" - wool is more uniform in fineness from body wool to the britch.
5. "Denser fleece" or "open fleece" - more or less wool fibers per square inch of body area.
6. "Shears more pounds of clean wool" - less yolk and foreign matter in wool.
7. "More belly wool on the sides" or "less belly wool on the sides" - belly wool is objectionable. It is coarse, short, and opened.

8. "Brighter fleece" - refers to color of fleece.
9. "More distinct crimp" - the natural waviness of the wool fibers.
10. "Tippy" - a wool with more than the usual amount of tip.
11. "Coarse on the britch" - the wool is coarse in the area of the rump and legs.
12. "Runs out on the britch" - the wool gets much coarser in the britch.
13. "More open face" or "more closed face" - the animal has more or less wool in its face.
14. "Kimpy" - a term used to describe coarse fibers that cannot be dyed.

FAT LAMBS - The same factors (muscling, finish, and dressing percentage) considered in judging steers are considered in judging lambs. The per captia consumption of lamb and mutton in the United States is approximately 4 pounds, and a large percent of this consumption is lamb. Lamb is usually cut into retail cuts, while the carcasses of mutton and older sheep are used for processed meats. The student should be able to determine the age of the sheep by examining the teeth.

Transparency No. 4

The same system, the step system, used in judging cattle should be used in judging lambs.

Since the length and density of the wool or fleece vary greatly among sheep, and the finish and flesh covering of sheep can only be roughly estimated without handling, the student must handle the limbs in a class to be able to determine their finish and fleshing. To determine finish and fleshing, the student should place the open hand with fingers close together over the back and rib section. Light pressure is applied to the animal and a slightly lateral, forward, and backward motion is made by the hand. The student should feel of the top of the shoulders, loin, and rump. If more careful handling is desired, they must use both hands and feel of the ribs and dock. With experience, the student should learn to determine the finish of sheep with a fast inspection.

The weight of the lamb is important; the ideal size of market lambs, based on consumer demand, weighs from 75 pounds to 105 pounds. A lamb weighing within these limits will yield a carcass weighing from 35 pounds to 55 pounds.

FAT LAMBS JUDGING BLANK

	1	2	3	4
Weight				
General Appearance				
Mutton type. General outline broad, deep; compact, blocky, low-set				
Size for age. Large, early maturing				
Symmetry. Straight topline, trim underline, uniform width; not paunchy, leggy, or rangy; smooth, stylish				
Conformation				
Head - not too large or too small for size of body, short; forehead broad, wide between the ears				
Neck - short, thick, full at junction with shoulder				
Brisket - wide, rounding, moderately prominent				
Shoulders - compact on top, smoothly joined with neck and body; shoulder vein full, not open or rough				
Chest - wide, deep, full behind shoulder and in foreflank				
Back - broad, straight, short, strong				
Loin - wide, level, thick				
Ribs - well sprung, long, close together				
Flank - low				
Hips - msooth, not prominent				
Rump - long, wide to dock, level, smooth				
Thighs - deep, wide, plump				
Twist - deep, not cut up				
Legs - straight, short, strong				
Condition				
Brisket - plump, wide; full between shoulder and brisket				
Shoulder vein - full				
Shoulders, back, loin, ribs, and rump - deeply covered with firm, springy flesh				
Flank - full				
Dock - large, thick				
Leg of mutton and twist - thick, plump				
Quality				
Bone medium in size; features of head clean-cut, refined but not delicate; ears not coarse; shoulder not prominent				
Flesh smooth, firm, not flabby				
FINAL PLACING				

BREEDING SHEEP - There are considerable differences among the different breeds of sheep in their breeding habits, lamb production, and wool production; and there is a variation of individuals within a breed. Generally, producing ability, size, type, age, fleece, and health are factors considered in judging breeding stock. It is also necessary to handle breeding sheep in order to accurately judge them.

The degree of emphasis placed on the wool of breeding sheep will vary with the type of sheep the student is judging. The general rule in determining the value of wool, if 100 is a total value of all factors, is 5 to 15 percent for medium wool breeds, 25 percent for long wool breeds, 30 percent for crossbred wool breeds, and 40 to 60 percent for fine wool breeds.

There is considerable variation in wool on a sheep's body.

It is advisable to select breeding sheep that have a good covering of dense wool with a 2 1/2 inch or more staple length. The fleece should be uniform in quality, bright in color, free from dark fibers, possess a bold crimp and character.

Swine

Terms used to describe swine are as follows:

Market and Breeding Hogs

1. Terms used to describe muscling are "thicker at the tail, through the middle, and lower ham"; "more muscular ham"; "thicker through ham from tail to base"; "thicker through the stifle"; "wider underneath (more width between both front and hind legs)"; "more natural thickness down the top"; "more muscular, shapely shoulder".
2. The terms describing correct finish (1.0 to 1.4 inches average backfat, thickness) are "more correct turn over the top"; "trimmer jowl and underline"; "cleaner over the top"; "cleaner in the shoulder", "cleaner in the floor of the chest, crotch, and tighter at the base of the ham.
3. "Stronger topped" - a hog with a stronger back.
4. "Stetchier, longer" - a hog with more length of body.
5. "Longer-rumped" - a hog displaying more length from hocks to pins.
6. "Firmer finish" - a hog with a firm finish.

Breeding Hog Terms

1. "More size, scale, and ruggedness" - a large rugged hog.
2. Descriptive terms of the feet and legs are "heavier, more rugged bone"; "shorter, straighter, stronger pasterns"; "straighter legged"; "more correct length of leg".
3. A hog with sounder underline is said to have "more functional teats"; "more evenly spaced teats"; "more development"; "front teats placed farther to the front".
4. "More feminine (gilt) head", and a "more masculine (boar) head".

5. "More Duroc, Hampshire, Poland, China, etc., breed characteristics about the head".

MARKET HOGS - The most desirable market hog is one that the farmer can produce economically and will bring a top market price when sold for slaughter. Grade, dressing percentage, and weight are the three factors that determine the market value of hogs.

Transparency No. 5

Muscling and the amount of fat are the two principal factors that affect grade. Correctly finished, heavy muscled hogs are much more valuable than their over-fat, poorly muscled counterpart. The most desirable backfat thickness is from 1.0 to 1.5 inches.

The back fat probe is one of the best means of determining muscling and fat thickness. To secure an accurate measurement of the meatiness of hogs, the student should probe hogs at weights of 180 to 220 pounds. Equipment needed for making a back fat probe is a scalpel or knife, metal ruler, and a snare.

The directions for probing are as follows:

1. The knife blade or scalpel blade is wrapped with tape 3/8 of an inch from the tip. The tape prevents the blade from going too deep.
2. The hog is restrained with a nose snare.
3. The knife is inserted through the skin at a right angle to the hog's body (at the points indicated on the transparency).
4. The ruler is inserted in the cut and is slanted at a 90 degree angle to the pig's back.
5. In a decisive push, the ruler is forced through the fat to the muscle.
6. The clip on the ruler is pushed down to the skin. The student should be sure there is not any downward pressure being applied to the ruler and that it is resting firmly against the muscle tissue. The ruler is removed, and a reading is made of the measurement.
7. For accurate results, the probe measurements are made at three locations on both sides of the pig for a total of six probes.
8. The six measurements are totaled and divided by six to determine the average backfat depth.

Amount of fill, trimness of middle, and the amount of fat affect the dressing percentage of market hogs. The average hog dresses about 70 percent; hogs yielding less than 70 percent are less valuable, while those dressing more than 70 percent are more valuable, if the higher dressing percentage is not caused by excessive finish.

The most desirable weight for market hogs is 200 to 230 pounds. Heavier hogs have more fat tissue in proportion to lean. Hogs weighing less than 200 pounds are usually discounted, for they have a lower dressing percentage.

Other factors that the student should consider are weight for age (at least 200 pounds at 180 days), rate of gain (minimum of 1.6 pounds per day after weaning), length of carcass (29 inches minimum), and size of loin eye along with the lean cuts. All of these factors are not available to the student participating in a judging contest; nevertheless, they are important in selecting market hogs.

HOG JUDGING BLANK

	1	2	3	4
Weight				
General Appearance				
Type. Deep throughout, medium width, medium low-set, Neither "rangy nor "chuffy"				
Size for age. Large, early maturing				
Symmetry. Moderately long and evenly arched topline; straight trim underline; uniform width; balanced proportions; smooth, Not low at shoulders				
Conformation				
Head - medium in length of snout and flace; broad between eyes and ears				
Jowl - medium-sized, not pendulous; smoothly joined to shoulder, trim, Free from wrinkles				
Neck - short and deep; thickness in proportion, joining head and shoulders smoothly				
Shoulders - compact on top, deep, smooth, even with sides; not prominent				
Back and loin - strong, evenly arched; medium, uniform width				
Sides - deep, long, straight, full; ribs long, carrying fullness well down				
Belly - trim, smooth and firm, without wastiness; underline straight and smooth, not cut up in flank				
Rump - long, medium width, rounding slightly from loin to tailhead, not drooping; tail not set too low				
Hams - broad, thick, deep, well fitted at base, firm and smooth				
Legs - medium length, straight, set squarely; well apart; pasterns nearly upright; toes together				
Condition				
Body - moderately wide, smooth				
Jowl and cheeks - light, plump				
Shoulders, back, loin, and rump - smoothly covered with flesh				
Sides - full and even				
Hams and twist - thick, plump, firm				
Quality				
Bone - legs smooth, neat, tapering; feet medium-sized; snout not coarse; shoulder not prominent; tail fine				
Skin - smooth, free from wrinkles on face, jowl, shoulder loin, side, or ham; ears fine texture, medium sized, neatly attched				
Hair - fine, straight, lying close to body				
Flesh - smooth, even, firm and free from flabbiness at jowl, foreflank, back, belly, and ham				
Dressing Percentage				
High as shown by trim middle, approved form, high condition, and superior quality				
FINAL PLACING				

Breeding Swine

The judge of breeding swine should select the animal that will produce an economical, top market hog. The success of a hog breeder is influenced by their ability to select and retain the most productive breeding animals. In addition to selecting breeding swine on type, which includes sex and breed character and the same factors considered in selecting market hogs, the student should be taught to use both production records and type as a basis of selection. Litter records, gaining ability, and backfat probe are records that should be used in selecting breeding swine.

Dairy Cattle

The purpose of a dairy animal is to reproduce and to convert feed into milk; therefore, the factors one would consider in judging dairy cattle are those that are associated with reproduction and milk production. General appearance, dairy character, body capacity, and mammary system are the major factors; and these are covered on the following dairy judging score card.

DAIRY JUDGING BLANK

	1	2	3	4
Breed Characteristics				
Head - medium in length, clean cut; broad muzzle with large open nostrils; lean, strong jaw; full, bright eyes; forehead broad between the eyes and moderately dished; bridge of nose straight; ears medium size and alertly carried				
Shoulder blades - set smoothly against chest wall and withers forming neat junction with the body				
Back - strong and straight-appearing with vertebrae well defined				
Loin - broad, strong, and nearly level				
Rump - long, wide, top line level from loin to and including tailhead				
Hips - wide, approximately level laterally with back, free from excess tissue				
Thurls - wide apart				
Pin Bones - wide apart and slightly lower than hips, well defined				
Tail Head - slightly above and neatly set between pin bones				
Tail - long and tapering with nicely balanced switch				
Legs - wide apart, squarely set, clean-cut and strong, with fore-legs straight				
Hind legs - nearly perpendicular from hock to pastern; when viewed from behind, legs wide apart and nearly straight; bone flat and flinty; tendons well defined; pasterns of medium length, strong and springy; hocks cleanly molded				
Feet - short and well rounded, with deep heel and level sole				
Dairy Character				
Neck - long, lean, blending smoothly into shoulders and brisket; clean-cut throat and dewlap				
Withers - well defined and wedge-shaped with the dorsal processes of the vertebrae rising above the shoulder blades				
Ribs - wide apart, rib bone wide, flat, and long				
Flank - deep, arched, and refined				
Thighs - incurving to flat from the side; wide apart when viewed from the rear, providing sufficient room for the udder and its attachment				
Skin - of medium thickness, loose and pliable				
Hair - fine				
Body Capacity				
Barrel - deep, strongly supported, ribs wide apart and well sprung; depth and width tending to increase toward rear of barrell				
Heart girth - large, resulting from long, well-sprung foreribs, wide chest floor between front legs, fullness to the point of elbow				
Mammary System				
Udder - capacity and shape, long, wide, and of moderate length and depth. Extending well forward, strongly attached, reasonably level floor. Rear attachment, high and wide, quarters evenly balanced and symmetrical				
Texture - soft, pliable, and elastic. Well collapsed after milking				
Teats - iniform, of convenient length and size, cylindrical in shape, free from obstructions, well apart and squarely placed, plumb				
Mammary veins - long, tortuous, prominent and branching, with numerous large wells, veins on udder numerous and clearly defined				
FINAL PLACING				

Even though they are not used in the State and National Dairy Judging Contests, performance records and pedigree are useful and necessary in selecting dairy cattle.

Transparency No. 6

Since dairy cattle deficiencies or defects affect the placing of an animal, the student should learn the defects that will affect the placing of animals. The discrimination of an animal because of a defect will vary from slight to serious. A slight defect will have a minor influence on the animal's placing, while a major defect may cause the animal to be placed last.

4. Grades of Animals

Grading Cattle

The official standards for live cattle provide for segregation of animals according to their use, class, and grade. Cattle may be either slaughtered or retained as feeders; the class is determined by their sex. The classes are steers, heifers, cows, bulls, and stags. The grade is determined by the desirability of an animal for its particular use.

The difference between slaughter and feeder cattle is based solely on their intended use, rather than on specific identifiable characteristics of the cattle. Slaughter cattle are those intended for slaughter after being fed for sometime. Under certain conditions, specific kinds of cattle may be considered as feeders; and under other conditions, they may be considered as slaughter cattle.

The grades of slaughter cattle are intended to be directly related to the grades of the carcasses they produce. There are two standards used for grading slaughter cattle; these are quality grade standards and yield grade standards.

Since the National and State Future Farmers of America Livestock Judging Contests grading classes do not include yield grade standards, only a brief explanation of this standard is given.

Yield grading was initiated by the United States Department of Agriculture in June, 1965, for the purpose of providing a uniform method of identifying "quality" or "cutability" differences among beef carcasses.

The grades are based on the percentage yields of boneless, closely trimmed, retail cuts from the high-value parts of the carcass -- the round, loin, rib, and chuck -- which account for more than eighty percent of its value. However, the yield grades also reflect the differences in the total yields of retail cuts. The five yield grades are numbered 1 through 5, with the number 1 grade yielding the highest percentage of retail cuts and the number 5 grade yielding the lowest percentage. A carcass typical of its yield grade will usually yield about 4.6

percent more in retail cuts than the next lower yield grade.

SLAUGHTER CATTLE - The quality grades of slaughter cattle are based on conformation and quality. Conformation refers to the general body proportions of the animal and to the ratio of muscle to bone. The description of conformation in the United States Department of Agriculture Slaughter Grade Standards includes overall thickness and fullness of muscling and fatness in relation to the animal's skeleton, size, and muscular development. An animal may meet the conformation requirements for a grade by having either the overall thickness and fullness or the thickness of muscling specified.

Quality in slaughter cattle is determined by the amount and distribution of finish, the firmness and fullness of muscling, and the physical characteristics of the animal associated with maturity (age). As cattle get older and there are changes in the amount and distribution of finish and firmness of muscling, the standards require a greater development of other quality indicating factors.

The student can evaluate the muscling of an animal by observing the areas of the animal that are the least affected by fat; these areas are the round and forearm. The thickness and fullness of these two areas are the best indicators of an animal's overall degree of muscling.

The finish on an animal can be determined by observing the areas that deposit fat the fastest. These include the back, loin, rump, flank, cod or udder, twist, and brisket. As cattle increase in fatness, these parts appear progressively fuller, thicker, and more distended.

The width of the backs of thinly muscled, under-finished cattle is usually greater than the width through the center of the round. Their backs are also usually flat or slightly sunken on each side of the backbone. Thickly muscled, highly finished cattle are thicker through the rounds than they are through their backs.

With an intermediate degree of fatness, cattle which are thickly muscled will be about the same width through the round and backs, and the back will appear only slightly rounded. Poorly muscled cattle with an intermediate degree of finish will be considerably wider through the back than through the round and will be nearly flat across the back.

Transparency No. 7

The slaughter grades of steers, heifers, and cows are Prime, Choice, Good, Standard, Commercial, Utility, Cutter and Canner. Transparency No. 7 gives the maximum age limitations for each grade. The Commercial grade is for cattle over 48 months of age. There are not any age limitations for the Utility, Cutter, and Canner grades.

Transparencies Nos. 8a and 8b

Since the student would consider the same factors in grading feeder animals (feeder cattle or feeder calves), the following discussion pertains to both feeder cattle and feeder calves.

FEEDER CATTLE - The grade of feeder animals is determined by their logical slaughter potential as beef and their thriftiness.

The logical slaughter potential is the slaughter grade of the animal at that stage of its development. Animals expected to produce superior slaughter conformation have very thick muscling in relation to their height and length and have wide, deep, rugged frames. They also have moderately large bones and smooth, refined joints.

Thriftiness refers to the animal's ability to gain weight and fatten rapidly and efficiently. Extremely thrifty cattle are healthy with wide, roomy middles and well-sprung ribs, and they are alert and large for their ages.

While the grade of a feeder animal is determined by evaluating the animal based on the two previously mentioned factors, conformation and thriftiness, conformation or inherent muscular development is the most important single factor affecting the grade of a feeder animal. Conforamtion is determined by appraising the development of the animal's muscular system in relation to the development of its skeletal system.

The degree of fatness is not a factor in grading slaughter cattle. However, the grade standard includes a detailed description of the various parts of the animal; and the animal's appearance is influenced considerably by variations in fatness. The standards for all feeder grades describe animals that have a slightly thin covering of fat. If the animals being graded have a greater or lesser degree of fatness than that on which the standard is based, the student will need to make the proper allowance.

The standards for feeder cattle are designed to cover the full range of variability in cattle. At any stage in their development, cattle may grade as feeder or slaughter cattle. The slaughter grade of most feeder cattle generally would be lower than their grade as feeders. For example, Prime or Choice feeder cattle would grade only Standard as slaughter cattle. However, feeder cattle of the lower grades may have a relatively higher degree of development than their present conformation indicates. Since the carcass quality of such an animal would be relatively higher than its feeder grade. For example, an animal might have had a logical slaughter potential of the upper part of the Utility grade; therefore, its feeder grade would be Utility. However, if such an animal had a carcass quality equal to the upper part of the Standard grade, its slaughter grade would be Standard.

Maturity is not normally a factor in determining the grade

of feeder cattle, but the animal's maturity or age at the time it reaches its logical slaughter potential must be considered.

The grades and maximum ages of feeder cattle are Prime, 36 months; Choice, 42 months; and Good and Standard, 48 months. The Utility grade does not have an age limit.

Transparencies Nos. 9a and 9b

Grading Swine

As is true with the beef cattle grades, the grades of slaughter barrows and gilts are related to the grades of the carcasses they produce. To accomplish this, the slaughter barrow and gilt grades are based on two factors: (1) Quality of the lean, and (2) Expected combined carcass yields of the four lean cuts (ham, loin, picnic shoulder, and Boston butt).

Two general levels of quality are considered: One for hogs having the characteristics which indicate that the lean will be acceptable and one which will indicate that the lean is unacceptable. Since lean quality in hogs is not directly evident in barrows and gilts, the student must consider factors useful in indicating quality. These are the amount and distribution of external finish, firmness of fat, and firmness of lean.

The factors used to determine the carcass yields in the four lean cuts are the backfat thickness and the degree of muscling (thickness of muscling in relation to skeleton size).

Transparency No. 10

SLAUGHTER BARROWS AND GILTS - The four grades for slaughter barrows and gilts are U.S. No. 1, U.S. No. 2, U.S. No. 3, and U.S. No. 4. The six degrees of muscling recognized in the standards are very thick, thick, moderately thick, slightly thin, thin, and very thin. The minimum degrees of muscling for grades No. 1, 2, 3, and 4 are thick, moderately thick, slightly thin, and thin, respectively.

In each grade superior muscling is permitted to compensate for greater fatness at the rate of one full degree of superior muscling for a one-tenth inch increase in average backfat; and in the U.S. No. 1 grade, the reverse type of compensation is permitted at the same rate; one-tenth inch less fat compensates for a degree of inferior muscling. The variation in the degree of fatness has a greater effect on the yield of lean cuts than do variations in muscling.

To determine the degree of muscling, the student should consider the areas of the hog least affected by fatness. The ham is such an area. The thickness and fullness of the ham is a good indication of muscling. Likewise, the student may wish to observe those areas affected the most by fat. These are the edge of the loin, rear flank, shoulder, jowls, and belly.

In heavy, thickly muscled hogs, the hams will be thicker than the hog's back, the back will appear full and well rounded. Very fat swine will be thicker through their backs than they are through the hams.

Grading Sheep

The classes of slaughter sheep are ram, ewe, and wether; and the age groups are lambs, yearlings, and sheep.

The grade of slaughter lamb is determined generally by conformation and quality; however, maturity and other factors are considered.

Conformation includes the general body proportions and the ratio of meat to the bone, which are influenced by muscling and the animal's skeletal system.

Quality is determined by the animal's distribution and type of fat or finish. Finish in lambs is determined in the same manner as it is for swine and cattle; however, to accurately determine finish, the student will need to handle the animal. One method of determining finish is explained in the information on judging fat lambs.

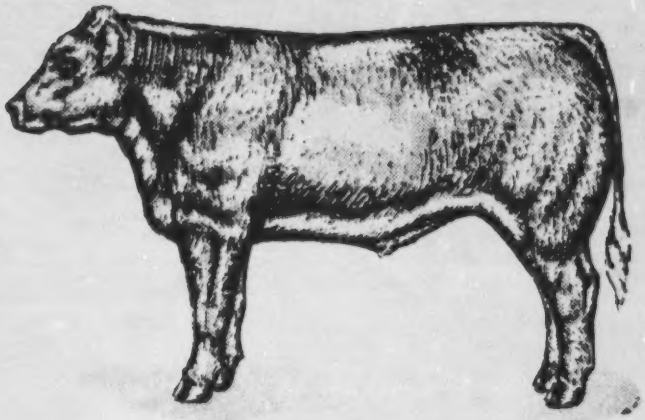
Transparency No. 11

SLAUGHTER LAMBS - The grades for slaughter lambs are Prime, Choice, Good, Utility, and Cull. To be in one of the above grades, the sheep must be a lamb.

References

1. "Official United States Standards for Grades of Feeder Cattle", U.S. Department of Agriculture, C & MS 183.
2. "Official United States Standards for Grades of Slaughter Lambs, Yearlings, and Sheep", U.S. Department of Agriculture, S, R, A 168.
3. "Official United States Standards for Grades of Slaughter Cattle", U.S. Department of Agriculture, S, R, A, 112.
4. "Standards, Inspections, Marketing Practices", U.S. Department of Agriculture, Title 7 -- Agriculture, Chapter 1, Part 53, Standards for Grades of Slaughter Barrows and Gilts.

SIDE VIEW OF THREE STEERS



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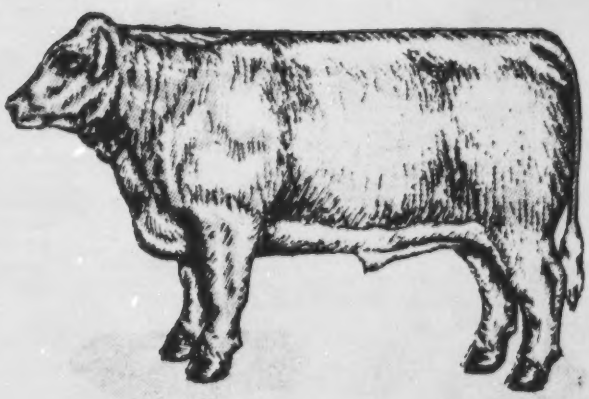

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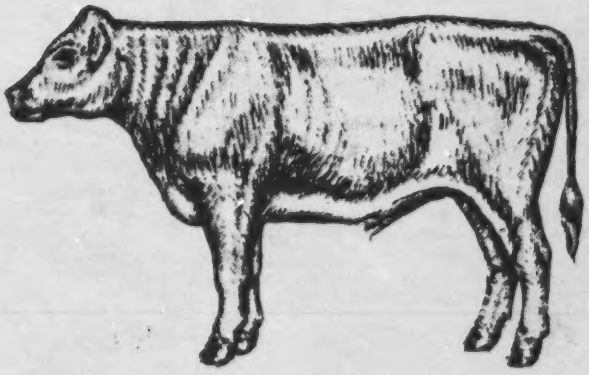

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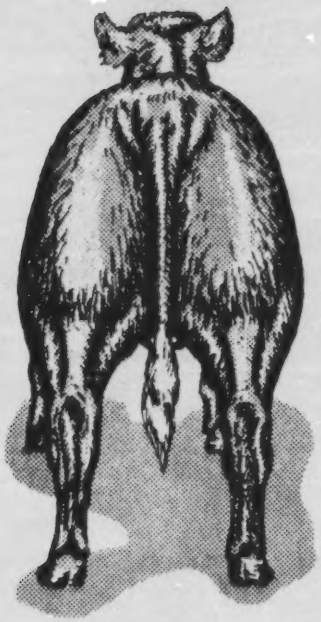
REAR VIEW OF THREE STEERS



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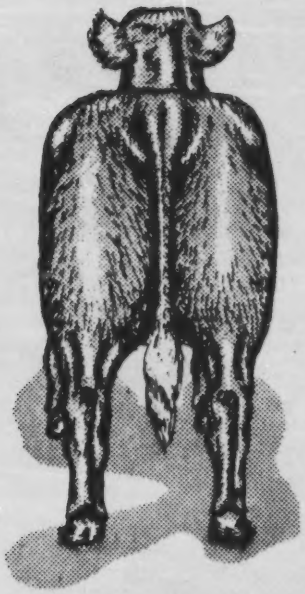


NO 2

NO 3

FRONT VIEW OF THREE STEERS

NO 1

NO 2

NO 3

921

922

TM - 3

AS II - XIV - 27

TEETH OF SHEEP OF DIFFERENT AGES

LAMB MOUTH

8 temporary incisors

YEARLING MOUTH

2 permanent middle incisors

2—YEAR—OLD MOUTH

4 permanent incisors

3—YEAR—OLD MOUTH

6 permanent incisors

4—YEAR—OLD MOUTH

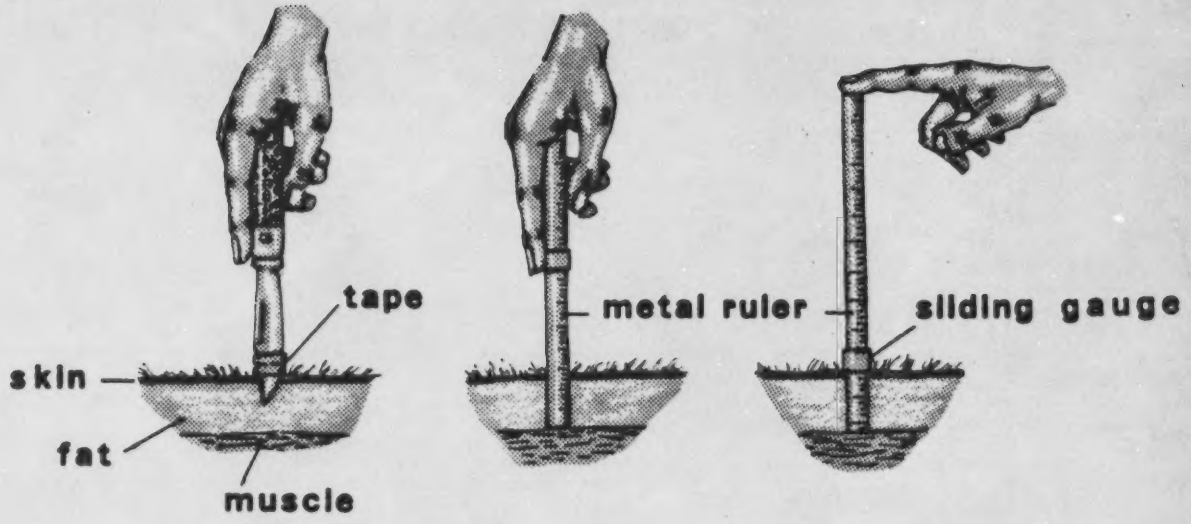
all permanent incisors

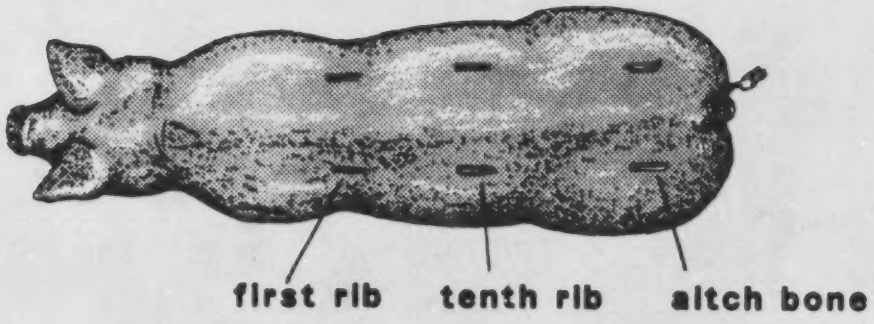
OLD SHEEP MOUTH

teeth well worn

923

MAKING THE BACK FAT PROBE





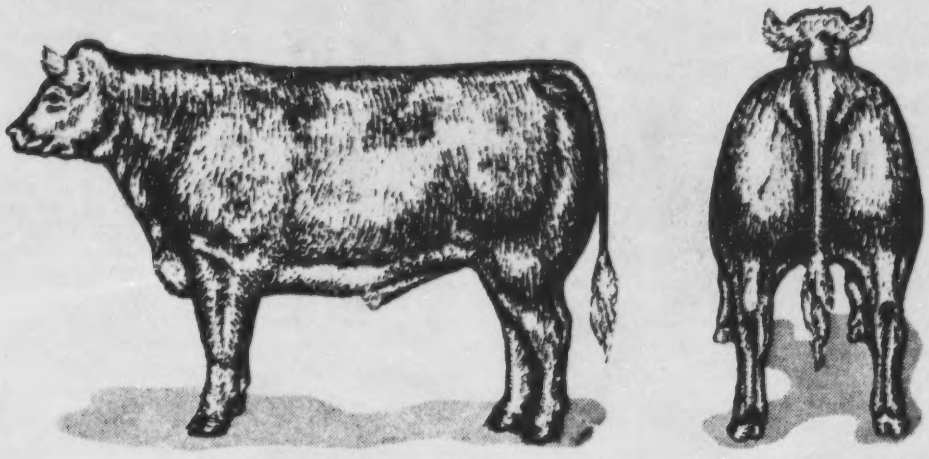
DAIRY CATTLE DEFECTS

AREAS AFFECTED	DEGREE OF DISCRIMINATION
EYES:	1. TOTAL BLINDNESS: DISQUALIFICATION
	2. BLINDNESS IN ONE EYE: SLIGHT DISCRIMINATION.
WRY FACE:	1. SERIOUS DISCRIMINATION.
PARROT JAW:	1. SLIGHT TO SERIOUS DISCRIMINATION.
SHOULDERS:	1. WINGED: SLIGHT TO SERIOUS DISCRIMINATION.
CAPPED HIP:	1. SLIGHT DISCRIMINATION.
TAIL SETTING:	1. WRY TAIL OR OTHER ABNORMAL TAIL SETTING: SLIGHT TO SERIOUS DISCRIMINATION.
LEGS AND FEET:	1. LAMENESS: PERMANENT AND INTERFERING WITH NORMAL FUNCTION: DISQUALIFICATION. TEMPORARY AND NOT AFFECTING NORMAL FUNCTION: SLIGHT DISCRIMINATION.
	2. BUCKED KNEES, BLEMISHED HOCKS, CROOKED HIND LEGS, WEAK PASTERNS: SERIOUS DISCRIMINATION.
	3. ARTHRITIS, CRAMPY HIND LEGS: SERIOUS DISCRIMINATION.
	4. ENLARGED KNEES: SLIGHT DISCRIMINATION.
LACK OF SIZE:	1. SLIGHT TO SERIOUS DISCRIMINATION.
UDDER:	1. BLIND QUARTERS: DISQUALIFICATION.
	2. ABNORMAL MILK: POSSIBLE DISQUALIFICATION. A SLIGHT TO SERIOUS DEFECT.
	3. UDDER DEFINITELY BROKEN AWAY IN ATTACHMENT: SERIOUS DISCRIMINATION.
	4. A WEAK UDDER ATTACHMENT: SLIGHT TO SERIOUS DISCRIMINATION.
	5. LIGHT QUARTER(S), HARD SPOTS IN UDDER, SIDE LEAK OR OBSTRUCTION IN TEAT (SPIDER): SLIGHT TO SERIOUS DISCRIMINATION.

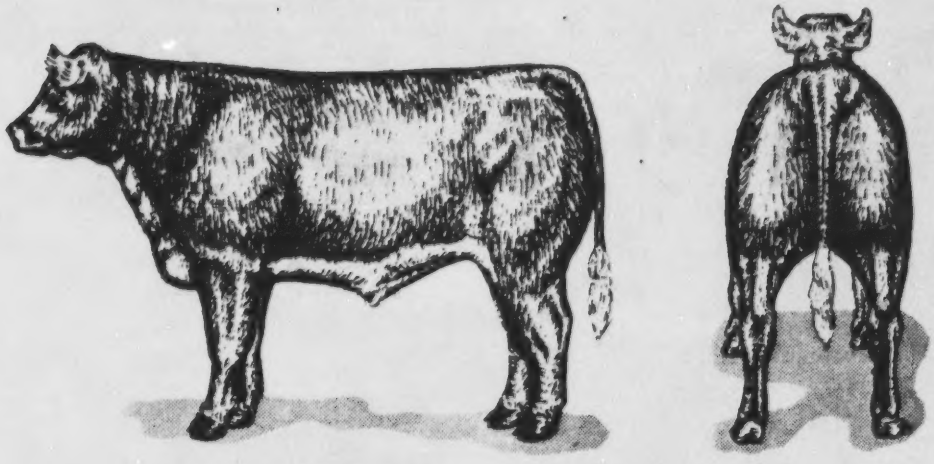
GRADES OF SLAUGHTER CATTLE AND MAXIMUM AGES

SLAUGHTER CATTLE	GRADE	MAXIMUM AGE (MONTHS)
STEERS AND HEIFERS	PRIME	36
	CHOICE	42
	GOOD	48
	STANDARD	48
	COMMERCIAL	48 AND OVER
	UTILITY	
	CUTTER	
	CANNER	
COWS	CHOICE	42
	GOOD	48
	STANDARD	48
	COMMERCIAL	48 AND OVER
	UTILITY	
	CUTTER	
	CANNER	
BULLS AND STAGS	CHOICE	42
	GOOD	48
	COMMERCIAL	48 AND OVER
	UTILITY	
	CUTTER	
	CANNER	

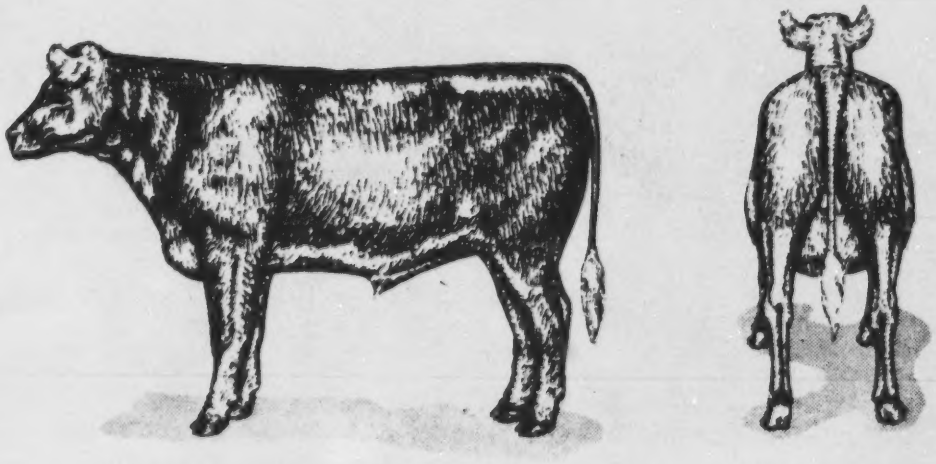
QUALITY SLAUGHTER GRADES OF CATTLE



PRIME

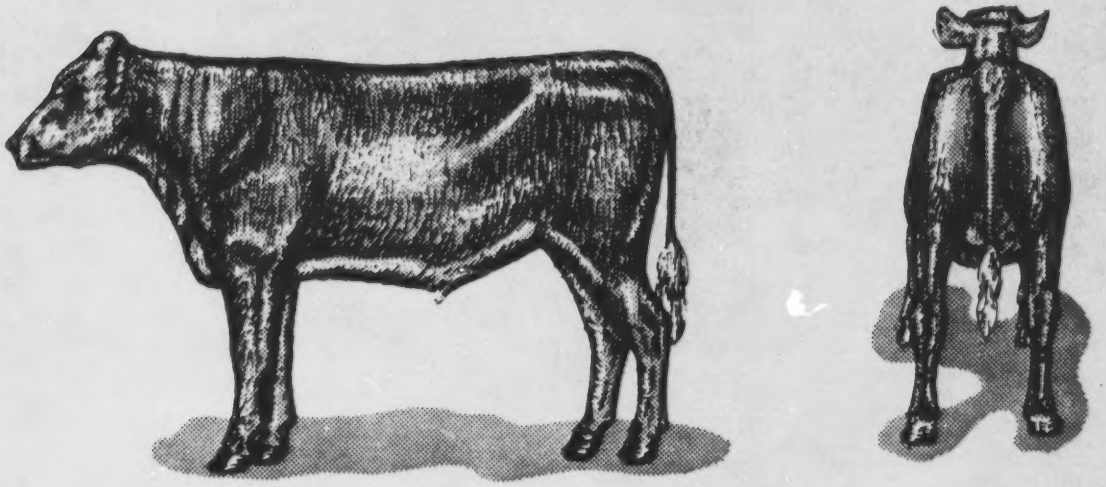


CHOICE



GOOD

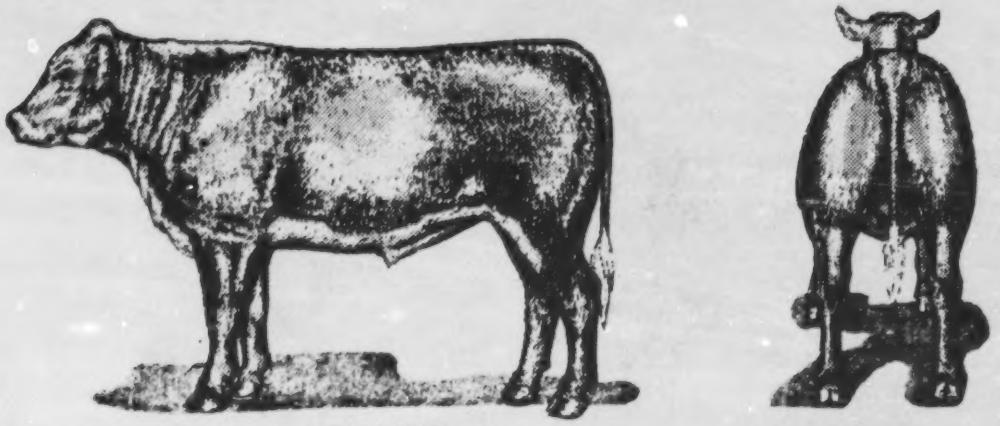
QUALITY SLAUGHTER GRADES OF CATTLE



STANDARD

UTILITY

CATTLE FEEDER GRADES



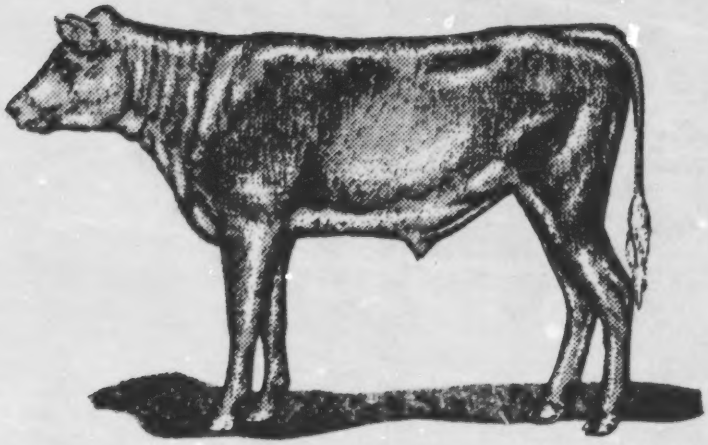
PRIME

CHOICE

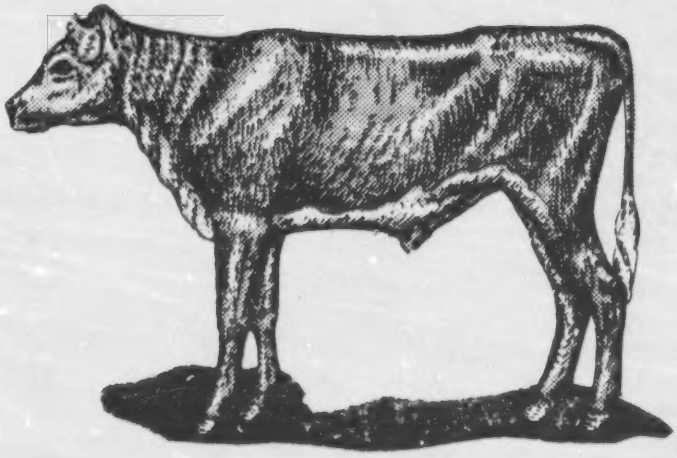
GOOD

923

CATTLE FEEDER GRADES

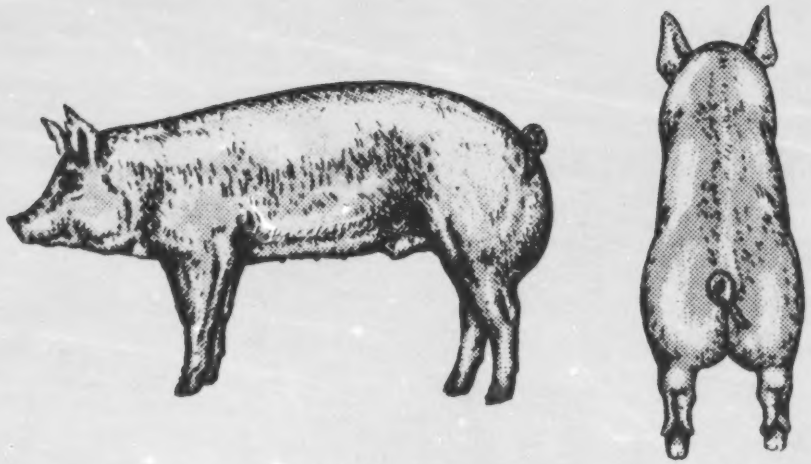


STANDARD



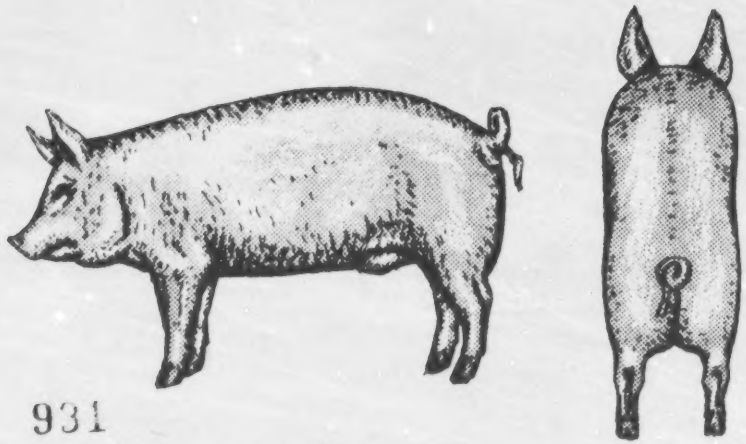
UTILITY

GRADES OF SLAUGHTER BARROWS AND GILTS



U.S. No. 1

U.S. No. 2



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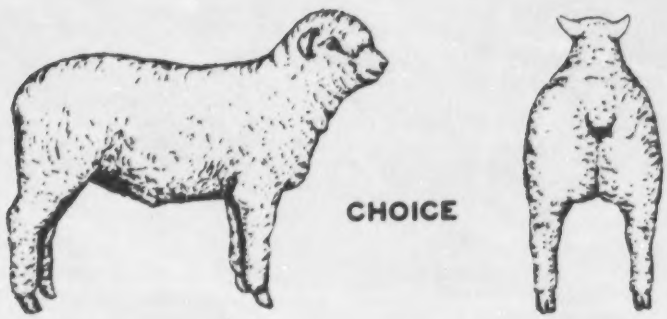
U.S. No. 3

U.S. No. 4

932

GRADES OF SLAUGHTER LAMBS



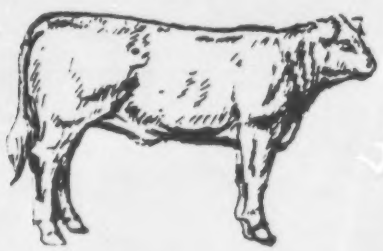
Glossary of Terms

1. Sex Characteristics - Those characteristics that distinguish one sex from another.
2. Finish - Refers to the amount of fat.
3. Lamb - A sheep of any sex about one year of age or younger.
4. Marbling - The intermingling of fat muscles. Marbling contributes to the juiciness, flavor, and palatability.
5. Muscling - The quantity of lean meat. The term is often used in describing conformation.
6. Mutton - A sheep or goat over one-year of age that was castrated before developing sexually.
7. Palatability - Refers to quality and the state of being palatable. Palatability affects tenderness, flavor, and juiciness.
8. Dressing Percentage - The percentage which the weight of the chilled carcass is of the live weight.
9. Breed Type - The desired form of an animal of a particular breed.

Student Activities

The activities in this section require the students to fill in the blanks, enumerate specific information, match terms, use formulas, and perform other activities.

1. Visual appraisal of animals is only an _____, and a more accurate appraisal can be made when _____ _____ are available.
2. Illustration of a side view of a steer



   a. The side view of an animal is normally observed in judging step No. _____.
   b. List some of the observations made in this step.
      1.
      2.
      3.
      4.

3. Illustration of a rear view of a steer.

   a. The rear view is observed in judging step No. _____.
   b. List some observations made in this step.
      1.
      2.
      3.
      4.

4. In the appropriate square, illustrate the different "turns to the topline" found in beef cattle.

Correct Turn ☐ Square-cornered top ☐ Triangular-shaped top ☐

5. Review the front view of the three steers shown in this topic and fill in the blanks.
   a. The steer with an excessively heavy, full brisket is steer No. _____.
   b. Steer No. _____ has a trim brisket, yet enough fullness to indicate quality.
   c. Steer No. _____ has very tight bones.
6. List the order and parts of a steer handled to evaluate finish.

7. List ways in which classes of animals can be grouped to reduce the number of decisions.

8. Match the statements with the market and breeding cattle terms by placing the letter identifying each statement in the square to the left of the correct term.

"Thicker, more muscular round"	a. An animal with smooth fleshing qualities
"More correct turn to the top"	b. More constitution
"Stronger topped"	c. Strong back
"More spring of rib and deeper heart girth"	d. Good muscling qualities
"More refined head"	e. A muscular round
"Beefier, heavier quartered"	f. More lean and muscle in hind quarters
"Smoother-fleshed"	g. A refined animal with quality

9. Three major considerations in judging steers are _____, _____, and _____ _____.
10. The _____, _____, and _____ of meat is affected by marbling.
11. Factors affecting dressing percentage of cattle are _____, _____, and _____
12. Explain the term, "breed type".

13. Describe the ideal male beef cattle sex characteristics for the different body parts listed below:

Shoulders -

Hair coat -

Head -

Testes -

Crest -

14. List terms used by judging to indicate muscling lambs.

a.
b.
c.
d.
e.

15. Match the statements with the wool terms by placing the letter identifying each statement in the square to the left of the correct term.

"More open faced"	a. Long wool fibers
"Coarse on the britch"	b. Finer wool
"More distinct crimp"	c. More fibers per square inch of body area
"Denser fleece"	d. Natural waviness of fibers
"Longer staple"	e. Coarse wool on the rump and legs
"Finer fleece"	f. Less wool on the face

16. Illustration of teeth of sheep

a. How old would a sheep be with the above teeth?

b. Draw the teeth of a sheep one year older.

17. Why is the weight of a market lamb important?

18. What determines the amount of emphasis placed on the wool when judging breeding sheep?

19. Match the statements with the market and breeding hog terms by placing the letter identifying each statement in the square to the left of the correct term.

"Stretchier, longer"	a. Firm finished animal
"Trimmer jowl and underline"	b. More length of body
"Thicker through the stifle"	c. A term used to describe correct finish
"Shorter, straighter, stronger pasterns"	d. A term used to describe muscling
"More evenly spaced teats"	e. A term describing feet and legs of breeding hogs
"Firmer finish"	f. A term describing the underline of a breeding hog

20. Adjust the backfat probe of a hog having an average backfat measurement of 1.3 inches and weighing 220 pounds to a 200-pound basis.

Answer: _____

21. List four lean cuts of a pork carcass that account for a large part of the value of a hog.

a. c.
b. d.

22. List the major factors considered in judging dairy cattle.

a.
b.
c c.
d.

23. How much will a defect influence the placing of a dairy cow?

24. List the considerations in evaluating cattle for slaughter grades.

a.
b.
c.

25. What is the difference in cutability in typical Yield Grade No. 1 and Yield Grade No. 2 slaughter cattle?

26. List factors that serve as the basis for yielding grading slaughter cattle.

a.
b.
c.
d.
e.
f.

27. How does finish affect the yield grade of slaughter cattle?

28. What are the purposes of slaughter cattle yield grades?

29. Why is the size of ribeye (12th rib) important on slaughter cattle?

30. How much change is there in the yield grade for each change of five percent in kidney, pelvic, and heartfat?

31. How much difference in carcass weight is required to change a carcass one full yield grade?

32. What is the live yield grade of a slaughter beef animal having .6 of an inch of fat over the ribeye; 1.5 percent kidney, pelvic, and heartfat; a warm carcass weight of 450 lbs.; and 10.4 inches of ribeye measurement?

33. List the areas considered in appraising muscling when muscling and fatness are the only considerations in evaluating slaughter cattle for yield grade.

a.
b.

34. List the parts of a beef animal that are observed in appraising fatness.

a.
b.
c.
d.
e.
f.
g.

35. Describe the appearance of a thickly muscled slaughter animal with a low degree of finish.

36. List the basis for grading feeder cattle.

a.
b.

37. The two categories in the standard for quality of pork are _____ and _____.

ANIMAL SCIENCE

Topic 2: Carcass Judging and Grading

Terms: All terms underlined are in the "Glossary of Terms".

Note: The teacher should obtain the grading standards for the different kinds of meat from the United States Department of Agriculture.

1. The Retail Cuts of Meat

Meat, being the basic food in most meals, furnishes a large percentage of the protein, vitamins, and minerals needed in the American's diet. As consumption has increased, the quality of meat and meat by-products has improved.

Meat is a food that can be prepared in many different ways; there are over one hundred and seventy-three different retail cuts of beef, veal, pork, and lamb. Many of these will not be found in the meat cases at one time, but a greater variety is being offered each year.

The identification of the retail cuts of meat, an area covered in the judging and grading of meat, is possibly more difficult than judging or grading meat; and to add to the confusion, many butchers call the identical cut by different names.

The student of Vocational Agriculture can learn the retail cuts by learning the parts of the carcass from which the retail cut was made. After learning this, the student can recognize a cut regardless of its name.

Transparency No. 1

Wholesale cuts of beef and pork are usually readily available. Beef is usually quartered or cut into wholesale cuts before it leaves the packing plant. This makes it much easier to handle. Since most of it is usually processed, pork wholesale cuts are easy to obtain. Certain cuts of lamb may be purchased by the wholesale cut; however, lamb is usually sold by the carcass.

The size and shape of the wholesale cut should give the student an idea of the size and shape of the retail cut, for its size and shape are influenced by the wholesale cut.

While the student is learning the wholesale cuts of meat, they should also observe the color of the meat, as the color will often help in identifying the kind of meat. Beef is generally a bright, cherry red in color, while pork will vary from a grayish pink to a rose color. Veal is light pink, and lamb is a pinkish red.

Transparency No. 2

Another method of identifying retail cuts is by the bone in the cut. The number, common name, and technical name of the different bones in beef, pork, and lamb carcasses are as follows:

1.	Neck bone	Cervical Vertebra
2.	Atlas	First Cervical Vertebra
		Thoracic Vertebrae 1 - 13 (up to 15 in pork.)

3.	Back bone	Lumbar Vertebrae (1 - 6 in beef and 7 in lamb and pork.)
4.	Button	Cartilage of spinous process
5.	Feather bone	Spinous process
6.	Finger bone	Transverse process
7.	Chine bone	Body of vertebra
8.	Slip joint	Sacroiliac disthrosis
9.	Tail bone	Caudal vertebrae 2 to 6 (varies in different carcasses.)
10.	Blade bone	Scapula
11.	Arm bone	Humerus
12.	Fore shank bone(s)	Ulna and radius
13.	Elbow bone	Olecranon process
14.	Breast bone	Sternum
15.	Rib cartilages	Costal cartilages
16.	Ribs	Ribs
17.	Pelvic bone	Pelvis
18.	Hip bone	Ilium
19.	Aitch bone	Ischium
20.	Leg bone	Femur
21.	Knee cap	Patella
22.	Stifle joint	Fmero-tibial Articulation
23.	Hind shank bone	Tibia
24.	Hock bones	Parts of the tibia and fibular tarsal bones

Learning the seven bone groups will also be helpful in identifying retail cuts. The bones within the seven groups are usually found in the retail cuts. Other bones are usually removed as the wholesale cut is being cut into retail cuts. The muscles found in the different groups are also given.

Transparencies Nos. 3a and 3b

Arm bone cuts - The arm bone is found in the retail cuts made from the shoulder. The round arm bone, humerus, is usually noticeable, and the cross ribs may be seen. The forearm, arm, and the brisket or middle rib muscles are usually found in these cuts.

Shoulder blade cuts - The blade bone and possibly the back and ribs can be observed in this group. The chuck tender and the inside and outside chuck muscle may be present in the shoulder blade cuts.

Rib cuts - This is one of the easiest to identify. It will contain the rib unless the retail cut was cut between the ribs. The rib eye and loin eye muscles will be in the rib cut.

Short loin cuts - This group contains the T - bone and the loin eye, tenderloin, and flank muscles.

Sirloin cuts - The sirloin or hip cuts include the pin bone, flat bone, and wedge bone. These may appear in a wide variation of shapes. The sirloin tenderloin, and tip muscles appear in the sirloin cuts.

Leg or round cuts - These cuts have a round bone, and the muscles in the round cuts are the top round, eye round, bottom, round, and tip.

Brisket cuts - These cuts contain rib bones, rib cartilage, and alternating layers of lean and fat.

2. Grading Beef Carcasses

Carcass beef may be graded into quality grades and/or yield grades. The carcasses in the State and National Meat Judging Contests are graded on quality grade standards only; however, the yield of lean cuts is important.

Yield grades are numbered one through five, with the better yielding carcasses grading number 1 and the lower yielding carcasses, depending upon specified quality, grading 2 through 5. The yield of boneless, closely-trimmed retail cuts determines the yield grade of a wholesale cut; and the carcass weight, area in the rib eye muscle, amount of external fat, and the amount of pelvic, kidney, and heart fat are the factors that determine the yield grade of a carcass. There is approximately 4.6 percent difference in the yields between each of the yield grades.

Transparency No. 4

In order to class and grade livestock according to quality grades, the student must consider and have a knowledge of the following factors:

1. Class or kind of meat.
2. Sex.
3. Quality.
4. Conformation grade.

A final grade is determined by using a composite of the above.

Determining Sex - The characteristics that may be used to accurately determine the sex of a beef carcass are the pizzle eye, often called the "button"; the bald spot; the glands; and miscellaneous characteristics.

Transparencies Nos. 5a and 5b

The pizzle eye, found in steers, stags, and bulls, is a gristly spot, varying from the size of a dime to the size of a quarter, just above the aitch bone. The bald spot, a cushion of lean meat, lies just above the pizzle eye and between the aitch bone and the fat covering above the rump. The cod fat on steers is easily distinguished by its rough, lumpy appearance. The udder of heifers is smooth, while the carcasses of old cows have the udders removed.

Miscellaneous characteristices that may be used to determine sex are the pelvic cavity and the shape of the aitch bone, ribs, and foreshank.

Class or kind - After the sex of the carcass has been determined, the student can more easily identify the kind of carcass. The carcass of a bull can be identified by the heavy development of the round, thick shoulders, and heavy, crested neck. Bull meat is also usually very dark and coarse.

A stag carcass, having the characteristics between a steer and a bull, has a more pronounced crest, slightly thicker rounds, and a larger pizzle eye than a steer carcass. The lean will usually be darker than the lean of a steer.

The carcasses of cows have much larger pelvic cavities, and their aitch bones are much straighter than those of heifer carcasses. The bones of cow carcasses are much whiter, and the chine bones may be ossified.

Quality - The age of the animal (maturity), the color and texture of the lean (rib eye muscle is used on ribbed carcasses to determine color and texture), degree of marbling, and firmness of the meat are the factors to consider in determining carcass quality.

Transparency No. 6

The Official United States Standards for Grades of Carcass Beef provide five maturity groups, which are lettered from "A" through "E". An animal with "A" maturity is very young, while one with "E" maturity group is very old. The ages appearing in the transparency are not a part of the official standard but are the presumed chronological ages associated with the characteristics identified.

Transparency No. 7

Carcasses with dark colored lean in the Prime, Choice, and Good grades may be reduced as much as one full grade; and Standard and Commercial grades may be reduced one-half of a grade. A carcass with soft fat and lean is usually discounted one-third of a quality grade.

Transparency No. 8

To determine marbling and firmness of meat, the student should observe the rib eye at the 12th rib. The different degrees of marbling are given in transparency No. 8.

Conformation - The conformation grade of the carcass should be determined by viewing the carcass from a distance of 10 to 12 feet. Plumpness and size of the rib eye muscle, the thickness of the carcass in relation to its length and depth, and the fullness and neatness in the regions of the more valuable cuts - loins, ribs, and rounds - are considered in evaluating conformation.

Transparency No. 9

The minimum marbling requirement for Choice grade carcasses varies from a small amount for the youngest carcass to a maximum of a modest amount for carcasses having the maximum maturity permitted in the Choice grade. This is also true in other grades.

Determining final grade - The final step in grading is to derive a composite grade based on conformation and quality, grade will include various combinations of these two factors. Each grade description has an example of how quality and conformation are combined into a final grade.

Principles governing these compensations are as follows:

1. A superior development of quality is permitted to compensate for deficient conformation, without limit, through the upper limit for quality.
2. The rate of compensation in all grades is on an equal basis. For example, a given degree of superior quality compensates for the same degree of deficient conformation.
3. The reverse type of compensation, a superior development of confomation for an inferior development of quality, is not permitted in the Prime, Choice, and Commercial grades.
4. The reverse type of compensation is permitted in all other grades except those listed in number 3. The maximum compensation in the reverse types is one-third of a grade; and the rate is on an equal basis, a given degree of superior conformation for the same degree of deficient quality.

3. As the beef carcass is judged, the student should remember that the consumer is principally interested in the appearance of the cut. Consumers usually never see the carcass from which the retail cut came. Conformation of the carcass determines the yields of the various cuts and the ratio of meat to bone, but variations in conformation are not usually evident in the retail cut. This is not to say that conformation is not important. The consumer considers other factors: color of the lean, texture, marbling, and the proportion of lean to fat and bone.

   The factors, conformation and quality, to consider in judging beef carcasses are in general the same factors that should be considered in grading beef carcasses.

Transparency No. 10

Conformation - The carcass with good conformation, as viewed from the back, has straight lines, which indicate a fuller, thicker, meatier carcass. A poor quality carcass may be described as hippy, ribby, flat in the rounds, and prominent in the shoulder joint. The carcass with ideal conformation will be thicker in the rounds and shoulders than it is in the rib and back area.

Quality - Factors affecting quality which were not discussed in the grading of beef are the texture of the lean, firmness of the lean, color of the lean, and the color and firmness of fat.

The best place on the carcass to observe all of these factors

is the rib eye, longissimus dorsi muscle, at the 12th rib.

Fine-textured lean will have a very few muscle bundles surrounded by tissue which separates them from other muscle bundles. Coarse-textured lean will have bundles that are surrounded by heavy connective tissue.

The color of the lean should be a bright red, and it should be firm and dry. Surface moisture on the rib eye is usually an indication of a low-quality carcass.

The fat should be dry, firm, flaky, and free from an oily or greasy appearance. A white to a creamy white fat is preferred by consumers. Three-tenths of an inch of fat covering at the twelfth rib, and a thin, uniform covering over the rest of the carcass is considered to be an ideal finish. Since the amount of fat determines the yields of salable meat, the student should evaluate the quantity of fat deposited on the various parts of the carcass. A properly finished carcass will have a heavier deposit of fat in the flanks, brisket, plate, udder or cod, rump, sirloin, and chuck than in other parts of the carcass.

4. Judging Wholesale Cuts of Beef

The class of wholesale cuts may be composed of either rounds, loins, ribs, or chucks. Regardless of the wholesale cuts used in the class, the same characteristics would be considered in determining their placing. These are youthfulness (age of the animal), firmness, color, texture, and marbling.

Transparencies Nos. 11a and 11b

The age of the animal from which the wholesale cut came can be determined by the condition and shape of the chine bones and sacral vertebra. In the round the aitch bone, showing a distinct curvature with a large knob in young animals, is the best indication of the animal's age if the ribs are being observed. The chine bones and buttons can be used to determine the animal's age in the wholesale chuck.

5. Grading Lamb Carcasses

Transparency No. 12

In addition to considering conformation and quality in grading lamb carcasses, the student should consider the proportion of the various wholesale cuts to the total carcass, the proportions of meat and bone in the carcass, and the quality of lean.

Transparency No. 13

Conformation - The conformation of a lamb, being influenced by the quality and distribution of external finish, is determined by muscle development and the skeleton system. The conformation of a lamb carcass is evaluated by averaging the conformation of the various parts, the proportion each cut is to the total carcass, and the desirability of each cut as compared with other cuts. A lamb carcass with ideal conformation will have a higher proportion of edible meat to bone and a high proportion of the carcass in the high price cuts.

Transparencies Nos. 14a and 14b

Quality - The texture and firmness of the carcass and marbling are the factors that determine carcass quality. These can best be evaluated by observing a ribbed carcass; however, most lamb carcass are not ribbed, so these characterisitics can not be observed directly. To evaluate the quality in unribbed carcasses, the student may observe the following:

1. The feathering on the inside of the ribs.
2. The streaking of fat in the inside flank muscles.
3. The firmness of fat and lean.

6. Judging Lamb Carcasses

Even though the lamb carcass class will consist of lamb carcasses only, the student should be able to estimate the ages of the different carcasses.

Transparency No. 15

Just above the "spool joint" on the lower end of the cannon bone, lamb carcasses hace a "break joint". At twelve to fourteen months of age, the cartilage in the "break joint" is replaced by bone. In order to grade a lamb carcass, according to Official United States Standards for Grades of Lamb, the carcass must have a "break joint".

By observing the color in the break joint, the shape of the ribs, the redness in the shank bone, and the color of the lean, the student can estimate the age of the animal at the time it was butchered. In young animals the break joint will be red, the ribs narrow and round, the shank bones white, and the lean light colored. Older lambs (12 months of age) will have white break joints and shanks, flat ribs, and lean with a dark red color.

Cutability and quality are the two principal factors to consider in judging lamb carcasses.

Cutability - Cutability, the amount of salable meat that may be cut from a carcass, is evaluated by determining the amount of finish and muscle development contained by the carcass. A lamb carcass with the proper amount of external finish will have a bluish tint visible along the back bone of the carcass. The student should also observe the amount of internal finish. The amount of pelvic, heart, and kidney fat is trimmable fat and affects the amount of salable meat.

A carcass with excessive finish, which must be removed before selling, is not as valuable as a properly finished carcass. The carcass with 0.1 of an inch of finish over the rib eye is considered to be properly finished.

The last areas of a lamb to be covered with finish are the leg and shoulder, back, sirloin, flank, cod or udder, and breast. These areas should also be observed in estimating finish.

The muscle development is not as valuable in estimating cutability as is finish, but it should be considered. The

leg is the best indication of the amount of muscle in the carcass; however, the width and fullness of the rack and loin should be observed. As is true in beef and pork carcasses, a muscular, properly finished lamb carcass will be wider in the leg and shoulders than it is in the loin and rack.

Quality - Quality in unribbed carcasses is determined by considering the color of the lean and fat, firmness of lean and fat, flank streaking, feathering of fat, and maturity.

The color of the lean may be determined by observing the color of the lean in the flanks and thoracic cavity. The proper lean color is a bright pink; the fat should be white. As the lamb ages, the lean color gets darker.

The feathering in the thoracic cavity and the streaking in the flanks will give an indication of the marbling in the muscles; however, these areas should be ignored in ribbed carcasses. The rib eye is preferred in appraising the amount and distribution of marbling. "Traces" of a "slight" amount of marbling in the rib eye is considered adequate.

7. Judging Pork Carcasses

The yields of the carcass in the four lean cuts (ham, loin, Boston butt, and picnic) and the quality of the lean are the two factors to consider in judging pork carcasses.

Finish is the most important factor affecting the yields of a pork carcass in the four lean cuts.

Transparency No. 16

The live weight of the hog will determine the maximum amount of backfat thickness that a pork carcass may have to be a quality carcass. In the above illustration, a hog weighing 230 pounds may have a maximum average of 1.3 inches of backfat to grade United States No. 1.

Transparency No. 17

Since the degree of muscling of hogs varies even in hogs having the same degree of finish, the Official United States Standards for Grades of Slaughter Barrows and Gilts specify a degree of muscling for each grade. The thickness of the ham and shoulders, the turn over the loin, and the depth of chines are the areas to consider in evaluating muscling.

8. Grading Wholesale Cuts of Pork

Transparency No. 18

To judge and to discuss the wholesale cuts of pork, the student must know the parts of the wholesale cut. Hams are used more often to make a class of wholesale cuts, but other wholesale cuts may be used.

Muscling and quality are considered in judging hams.

Muscling - A properly muscled ham is broad and deep in the face or butt end and has depth and width toward the hock. The

length of the ham may be determined to some extent by the packer or butcher, but it should be long if a large proportion of the total weight is going to be in the center section, the area of the center ham slices.

The student, to get a true picture of the meatiness of the ham, should also observe the outside fat of the ham. Commercial packers leave the lower part of the ham unskinned. The heel of the ham, under the skin, is usually filled with fat, which gives the ham a thicker appearance. Excessively fat hams should receive a lower placing.

Quality - The color of high quality hams is grayish-pink, and the exposed lean surface should be firm and fine textured. The exterior fat should be firm, dry, and white; the marbling should be uniform.

The lean in poor quality hams is dark in color, and the muscle near the bone is darker than the other lean. The poor quality ham is also usually soft and watery.

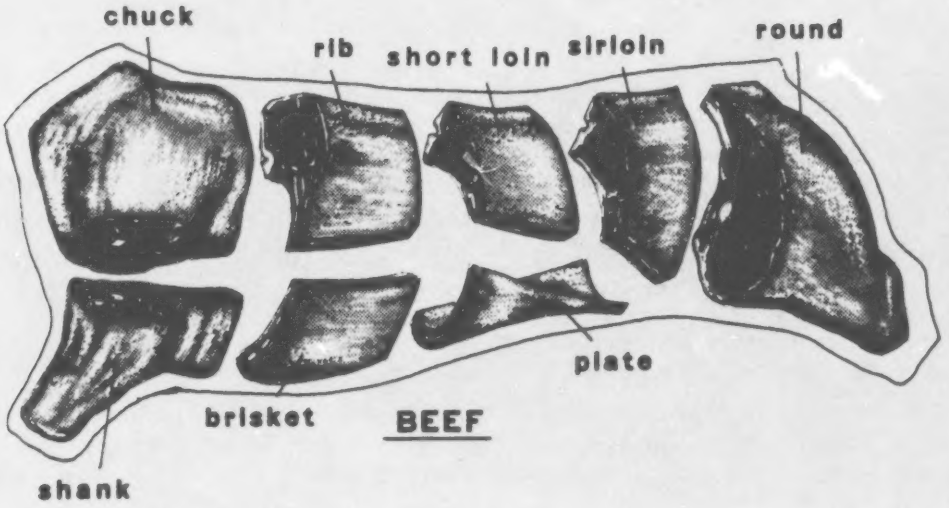
Transparency No. 19

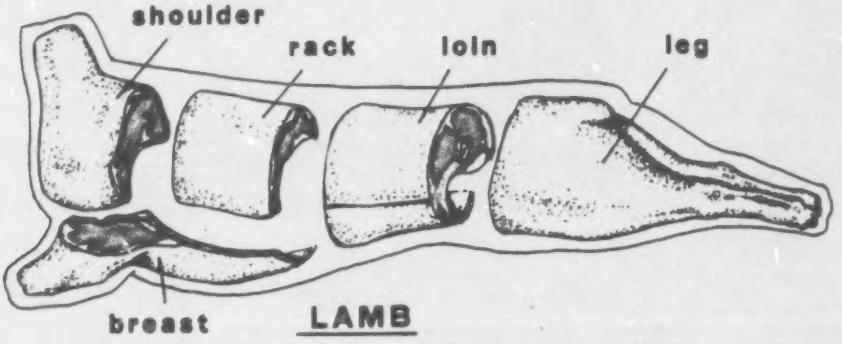
The hams in the above transparency illustrate a wide range of quality. Obviously, they are placed 1 - 2 - 3 - 4.

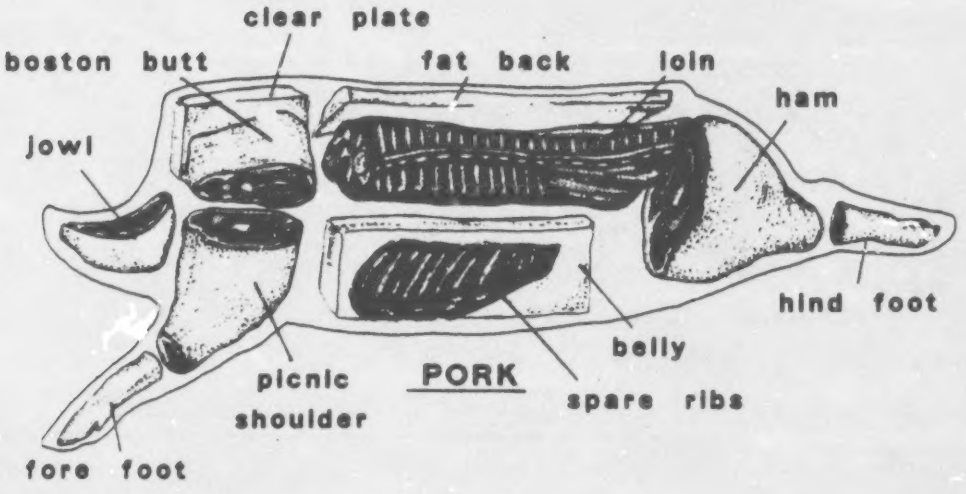
References:

1. "Meat Evaluation Handbook", National Livestock and Meat Board, Chicago, Illinois.
2. "The New Meat Manual", National Livestock and Meat Board, Chicago, Illinois.
3. "Meat Manual", National Livestock and Meat Board, Chicago, Illinois.
4. "Facts You Should Know About Beef", Swift and Company, Chicago, Illinois.
5. "Lessons on Meat", National Livestock and Meat Board, Chicago, Illinois.
6. "Cuts of Meat", Swift and Company, Chicago, Illinois.
7. "United States Department of Agriculture Grades for Beef", United States Department of Agriculture, Washington, D.C.
8. "Official United States Standards for Grades of Carcass Beef", United States Department of Agriculture, Washington, D.C.
9. "Official United States Standards for Grades of Lamb, Yearling Mutton, and Mutton Carcasses", United States Department of Agriculture, Washington D.C.
10. "Official United States Standards for Grades of Slaughter Barrows and Gilts", United States Department of Agriculture, Washington, D.C.

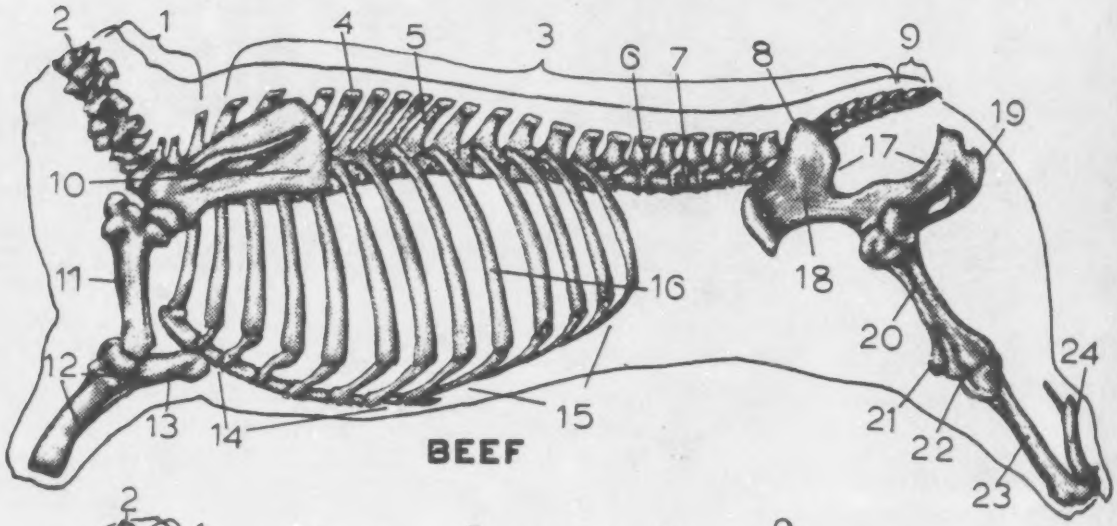
WHOLESALE CUTS



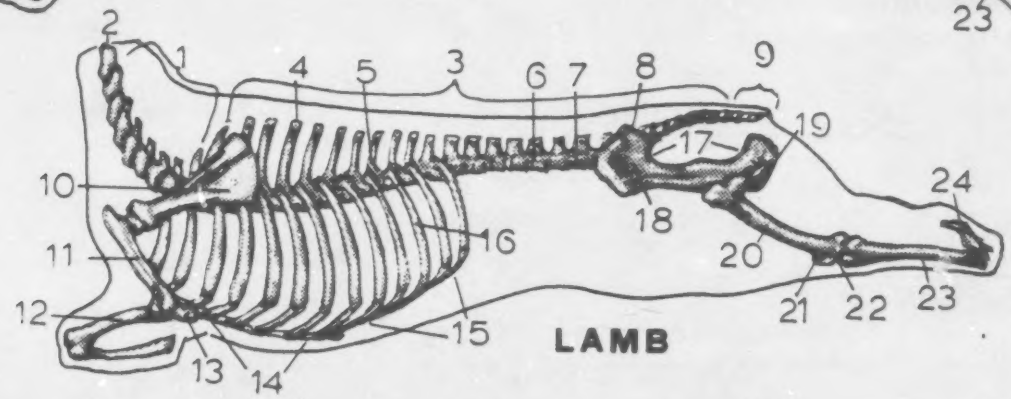




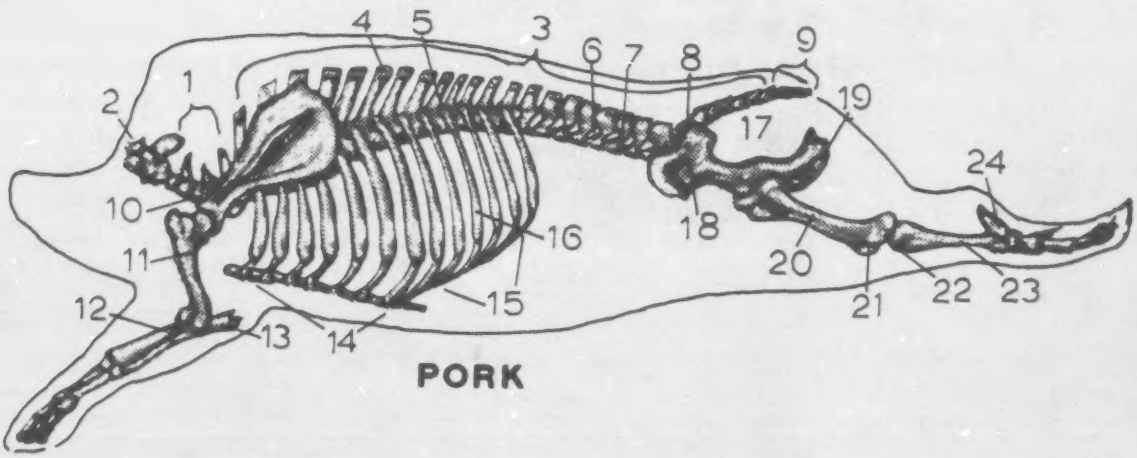
BONE STRUCTURE



BEEF



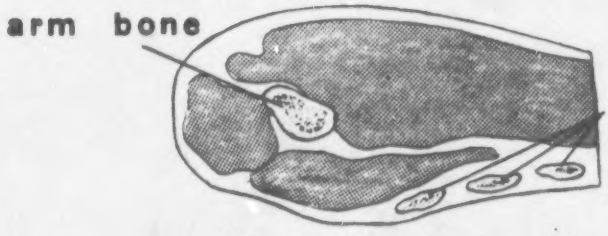
LAMB



PORK

SEVEN BONE GROUPS

ARM BONE



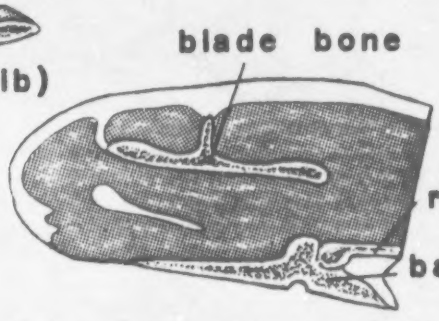
Shoulder Arm Cut

(near neck)

(near rib)

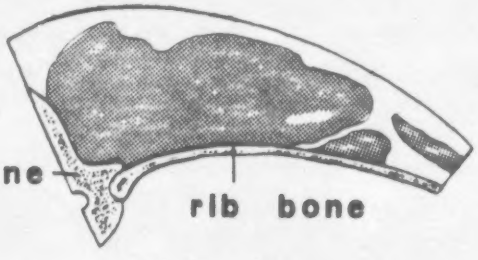
(center cuts)

BLADE BONE



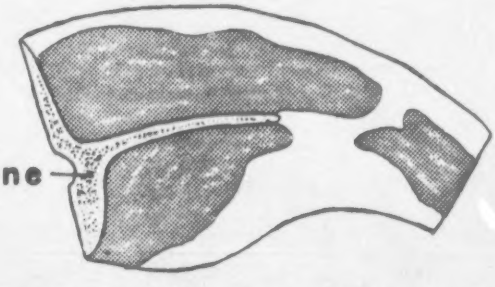
Shoulder Blade Cut

BACK BONE AND RIB BONE



Rib Cut

BACK BONE



Short Loin Cut (T—bone)

SEVEN BONE GROUPS

Pin Bone

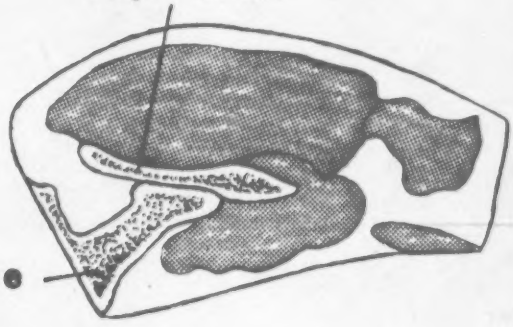
Wedge Bone

Flat Bone

HIP BONE

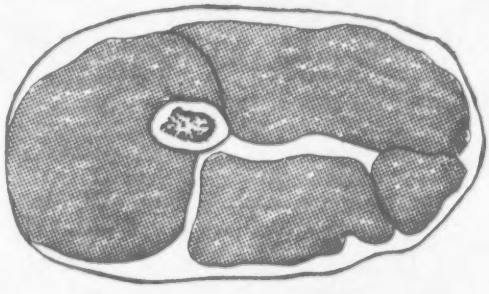
hip bone

back bone

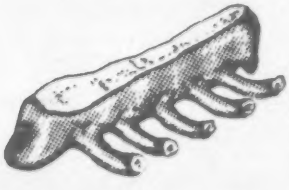


Hip Sirloin Cut

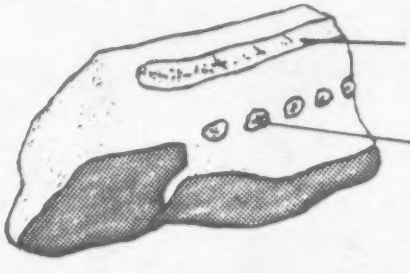
LEG OR ROUND BONE



Leg or Round Cut



BREAST AND RIB BONES



breast bone

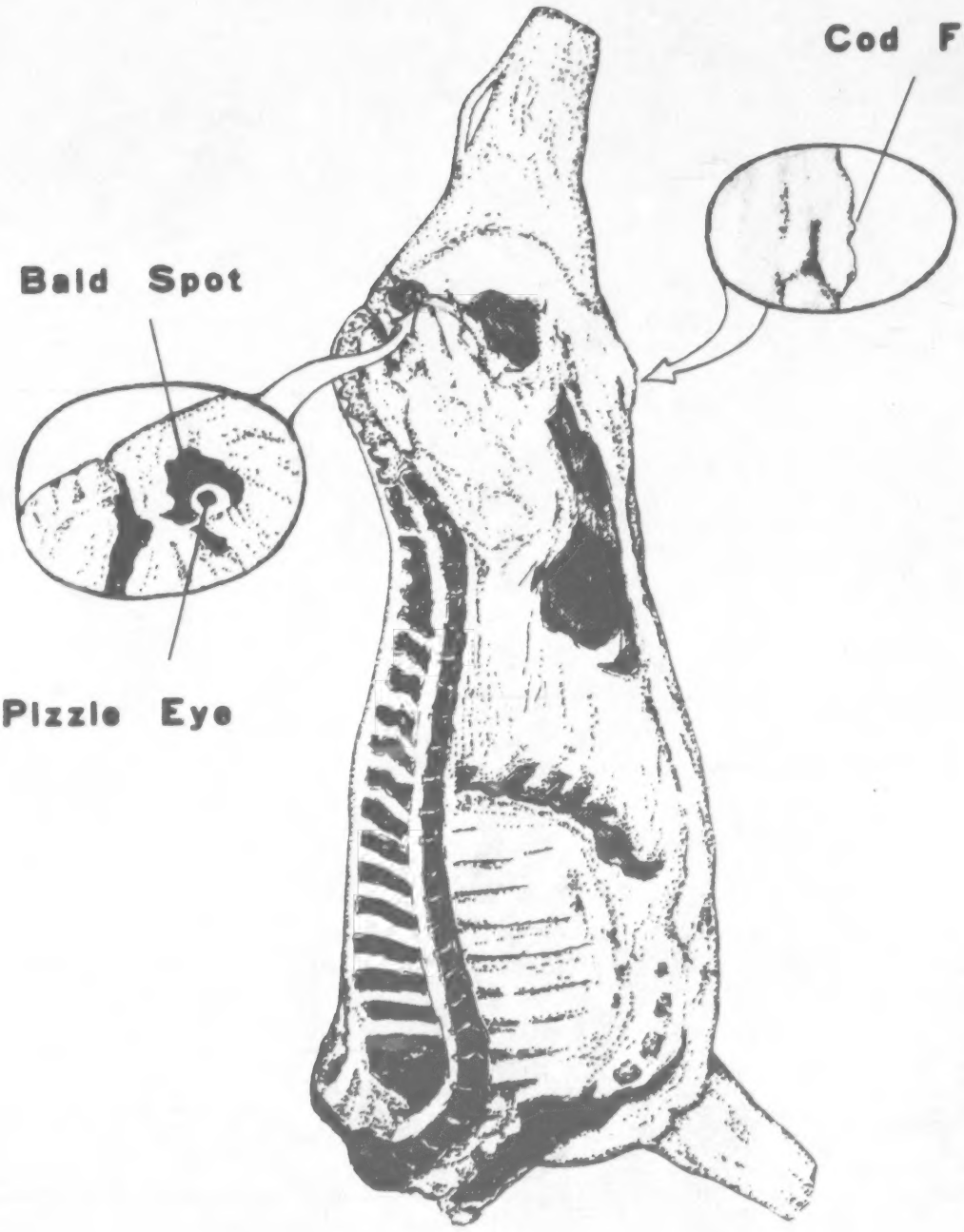
rib bone

Breast or Brisket Cut

CLASSIFICATION AND GRADES OF BEEF

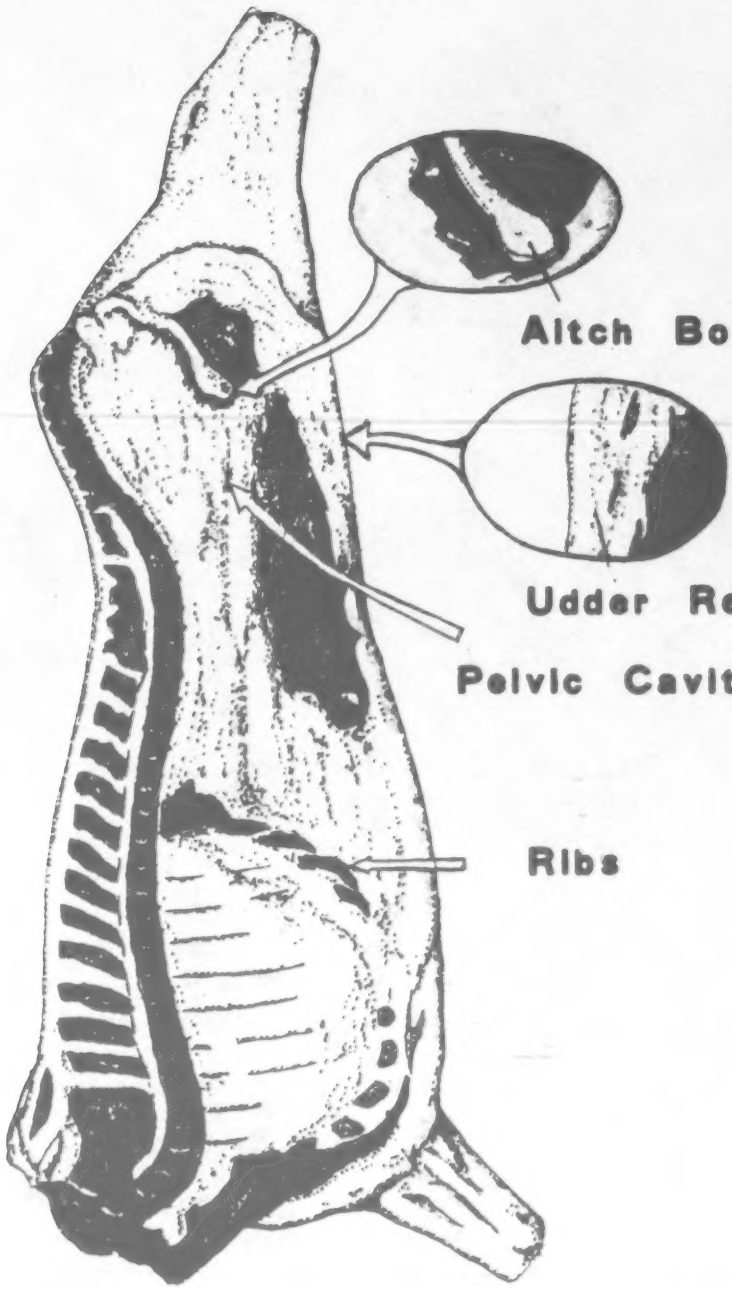
CLASSES	GRADES
Steers and Heifers	Prime, Choice, Good, Standard, Commercial, Utility, Cutter, Canner
Cows	Choice, Good, Standard, Commercial, Utility, Cutter, Canner
Bulls and Stags	Choice, Good, Commercial, Utility, Cutter, Canner

CHARACTERISTICS THAT DETERMINE SEX



STEER CARCASS

CHARACTERISTICS THAT DETERMINE SEX



HEIFER CARCASS

BEEF GRADES MATURITY DESCRIPTIONS

CARCASS REGION OBSERVED	A— 9mo.	A+ to B— 32 mo.	B to B+ 42 mo. B+ to C— 48 mo.	C+	E—
SACRAL VERTEBRAE	Distinct separation cartilagenous buttons present	Completely fused			
LUMBAR VERTEBRAE	No ossification buttons plainly evident	Nearly completely ossified	Completely ossified		
BUTTONS AT POSTERIOR END OF THORACIC REGION	No ossification buttons plainly evident	Some evidence of ossification	Partially ossified Moderately ossified		
VERTICAL THORACIC PROCESSES	Soft, porous, and very red	Slightly soft and slightly red	Tinged with red	Moderately hard and rather white	Hard and white
RIBS	Slight tendency toward flatness	Slightly wide and flat		Moderately wide and flat	Wide and flat
RIB EYE MUSCLE	Light grayish-red Very fine textured	Light red Fine textured	Tends to be fine textured	Moderately dark red and slightly coarse textured	Dark red and coarse textured

COLOR AND FIRMNESS OF MEAT GRADES

Grades	NORMAL FIRMNESS (LEAN)		NORMAL COLOR (LEAN)	
	Young	Old	Young	Old
PRIME	Medium Firm	Firm	Light Red	
CHOICE	Slightly Soft	Slightly Firm	Medium Light Red	
GOOD	Medium Soft	Slightly Soft	Slightly Light Red	
STANDARD	Soft	Medium Soft	Slightly Dark Red	
COMMERCIAL	Slightly Firm	Firm	Medium Dark Red	Dark Red
UTILITY	Soft and Slightly Watery		Slightly Dark Red	Very Dark Red

Ag II - XIV - 60

DEGREES OF MARBLING

1—VERY ABUNDANT

2—ABUNDANT

3—MODERATELY ABUNDANT

4—SLIGHTLY ABUNDANT

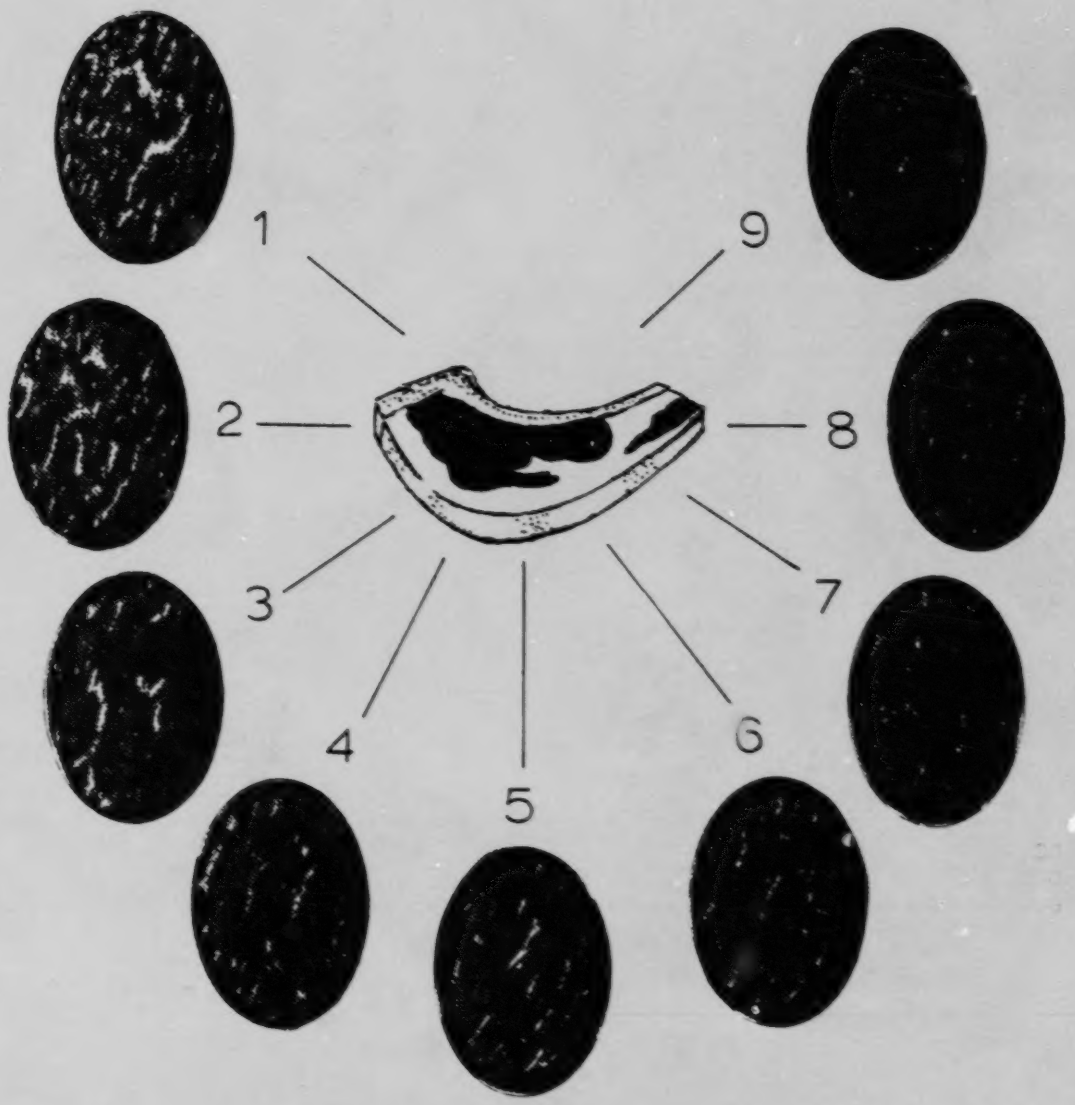
5—MODERATE

6—MODEST

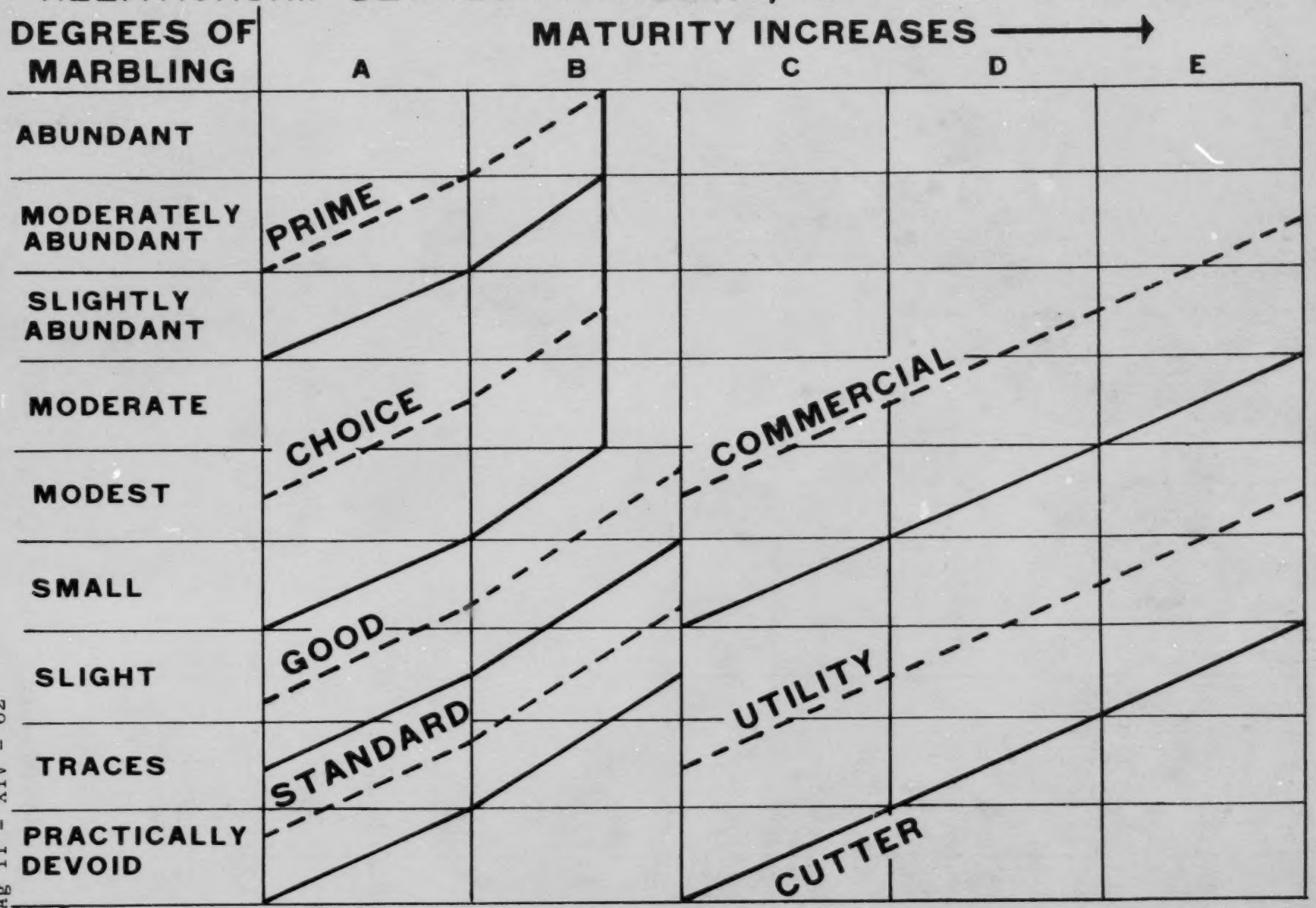
7—SMALL

8—SLIGHT

9—TRACES



RELATIONSHIP BETWEEN MARBLING, MATURITY AND QUALITY



Ag II - XIV - 62

961

962

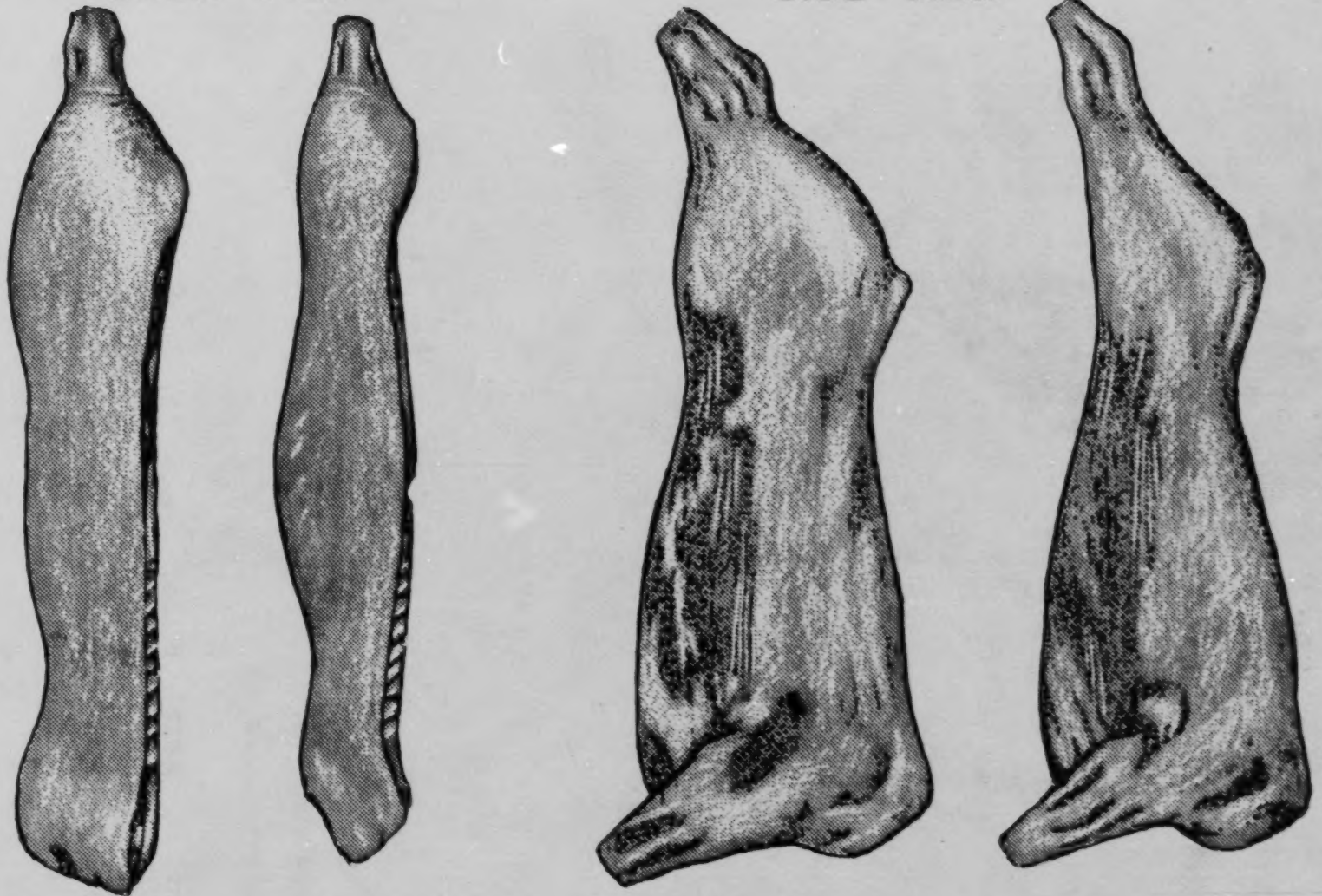
TM - 9

Ag II - XIV - 63

BEEF CARCASS CONFORMATION

BACK VIEW

SIDE VIEW



IDEAL POOR IDEAL POOR

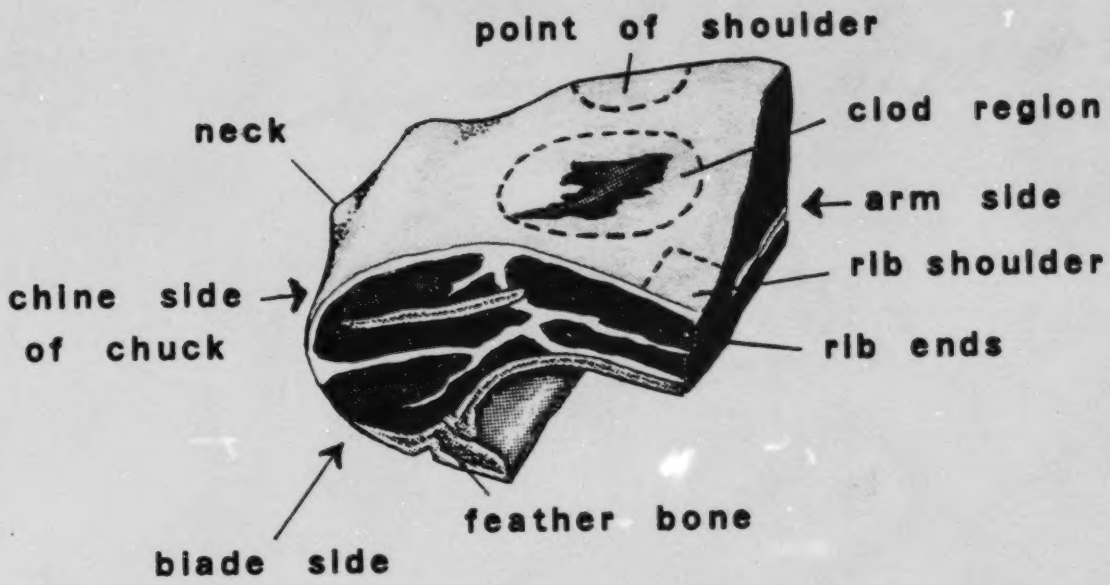
TM - 10

963

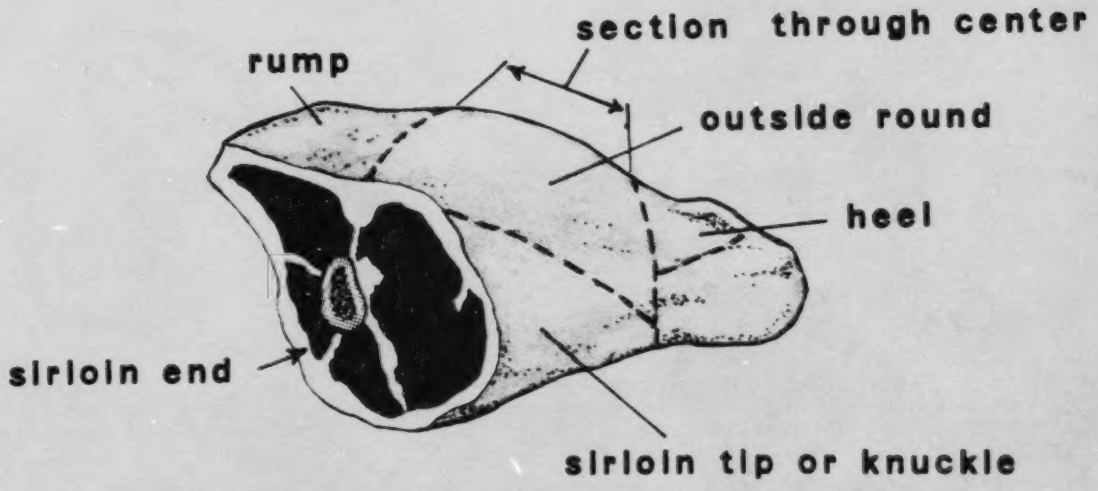
964

PARTS OF THE WHOLESALE CUTS-BEEF

PARTS OF THE CHUCK

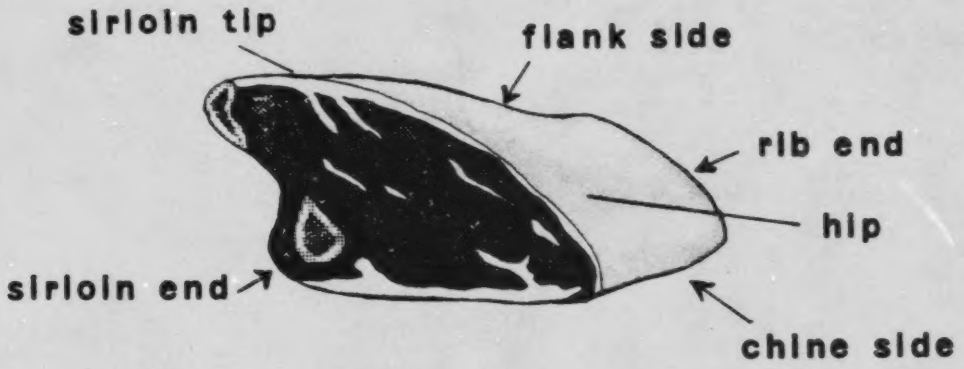


PARTS OF THE ROUND



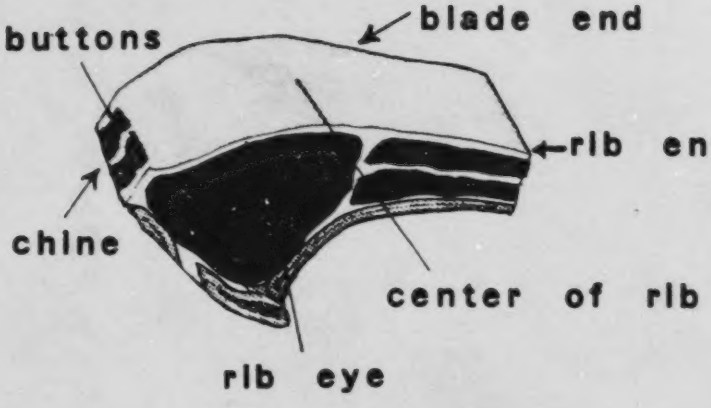
PARTS OF THE WHOLESALE CUTS OF BEEF

PARTS OF THE LOIN (SIRLOIN END VIEW)

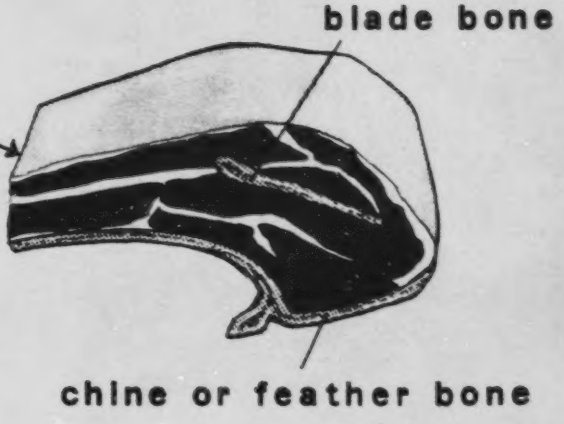


PARTS OF THE RIB

Eye End of Rib



Blade End of Rib



CLASSES AND GRADES OF LAMB CARCASSES

CLASS	GRADE
Lamb	prime, choice, good, utility, cull
Yearling Mutton	prime, choice, good, utility, cull
Mutton	choice, good, utility, cull

TM - 12

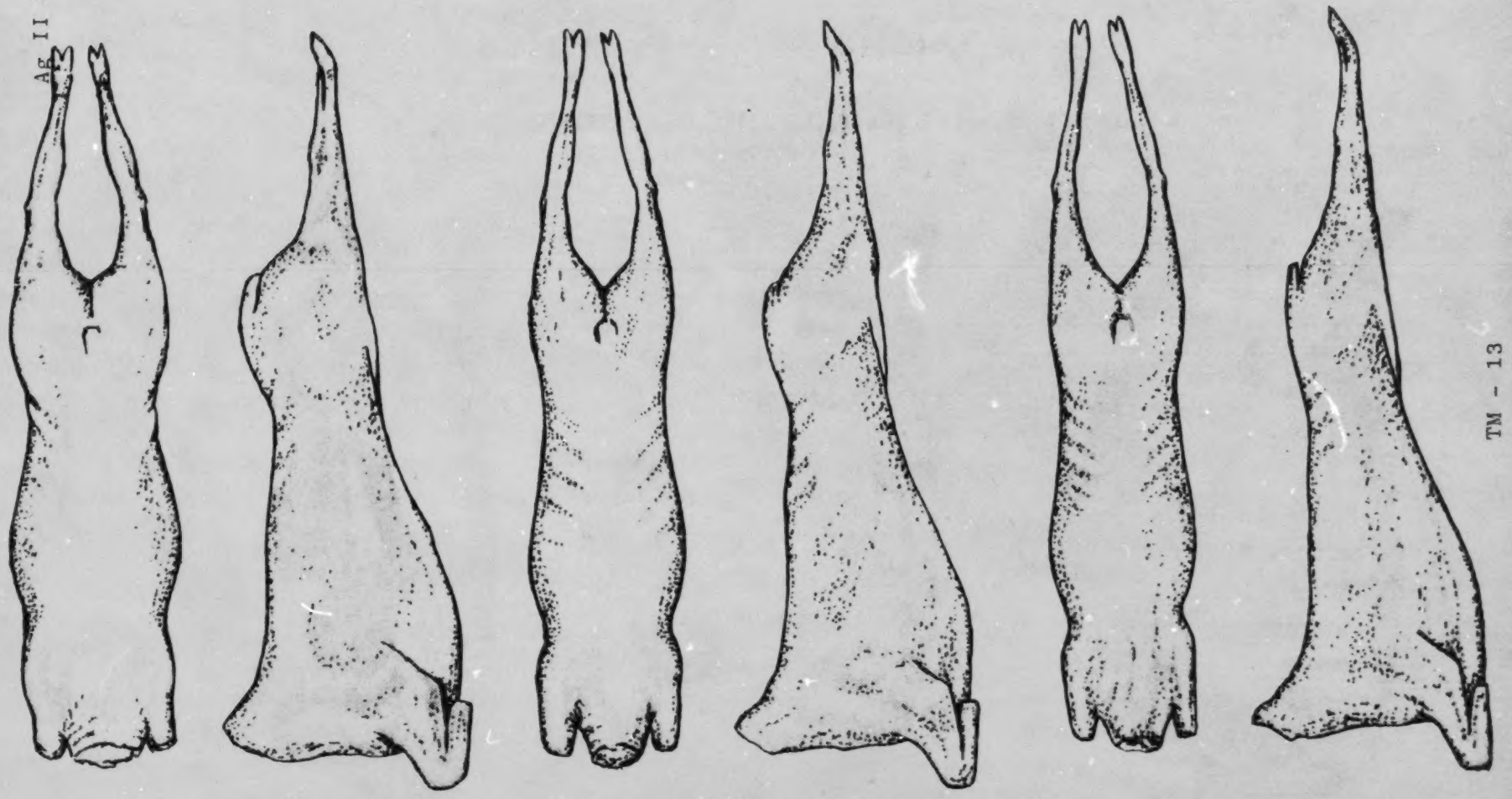
Ag II - XIV - 66

967

968

Ag II - XIV - 67

LAMB CONFORMATION



PRIME

CHOICE

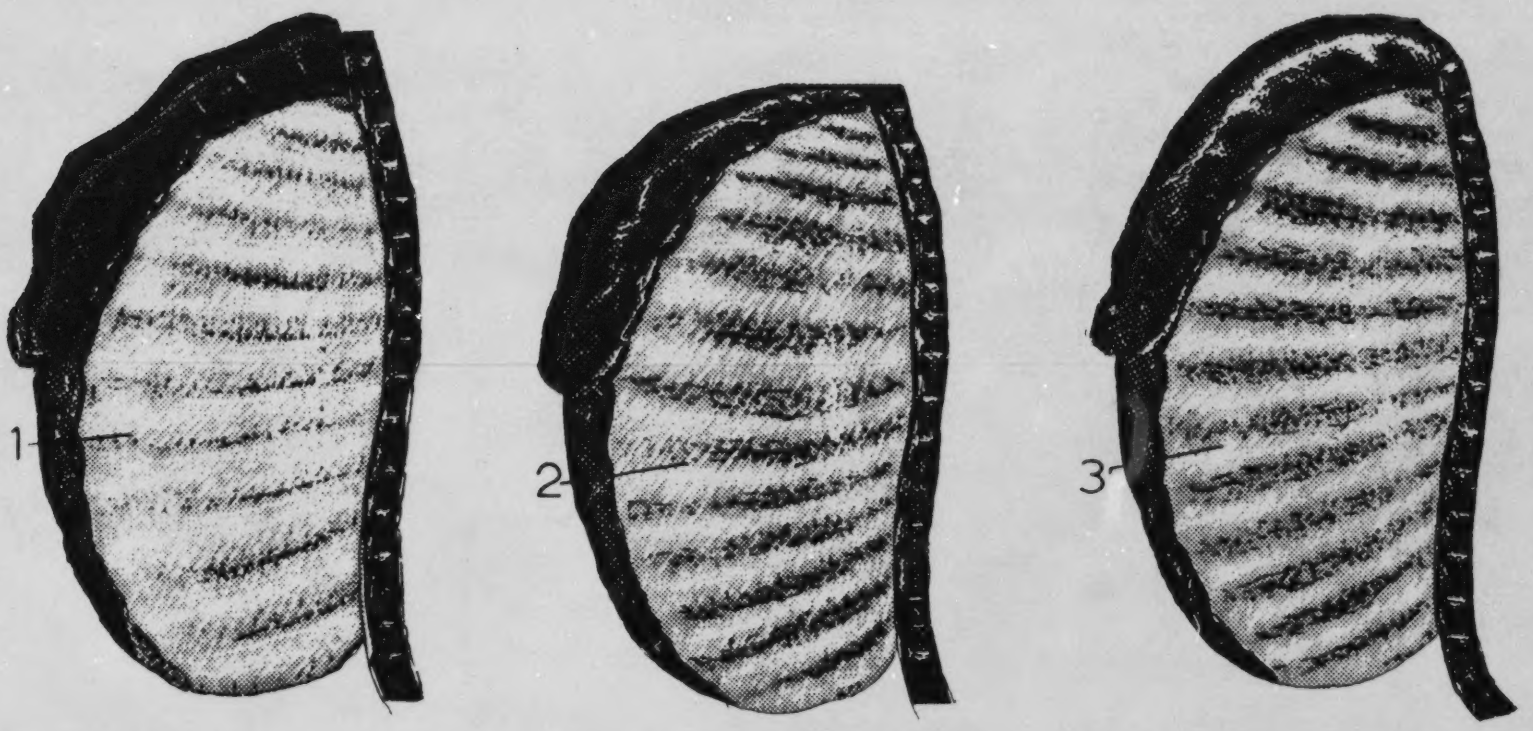
GOOD

969

970

TM - 13

FEATHERING IN LAMB CARCASSES



TM - 14a

Minimum Requirements For Lambs

	PRIME	CHOICE	GOOD
FEATHERING	1 Modest	2 Slight	3 Traces

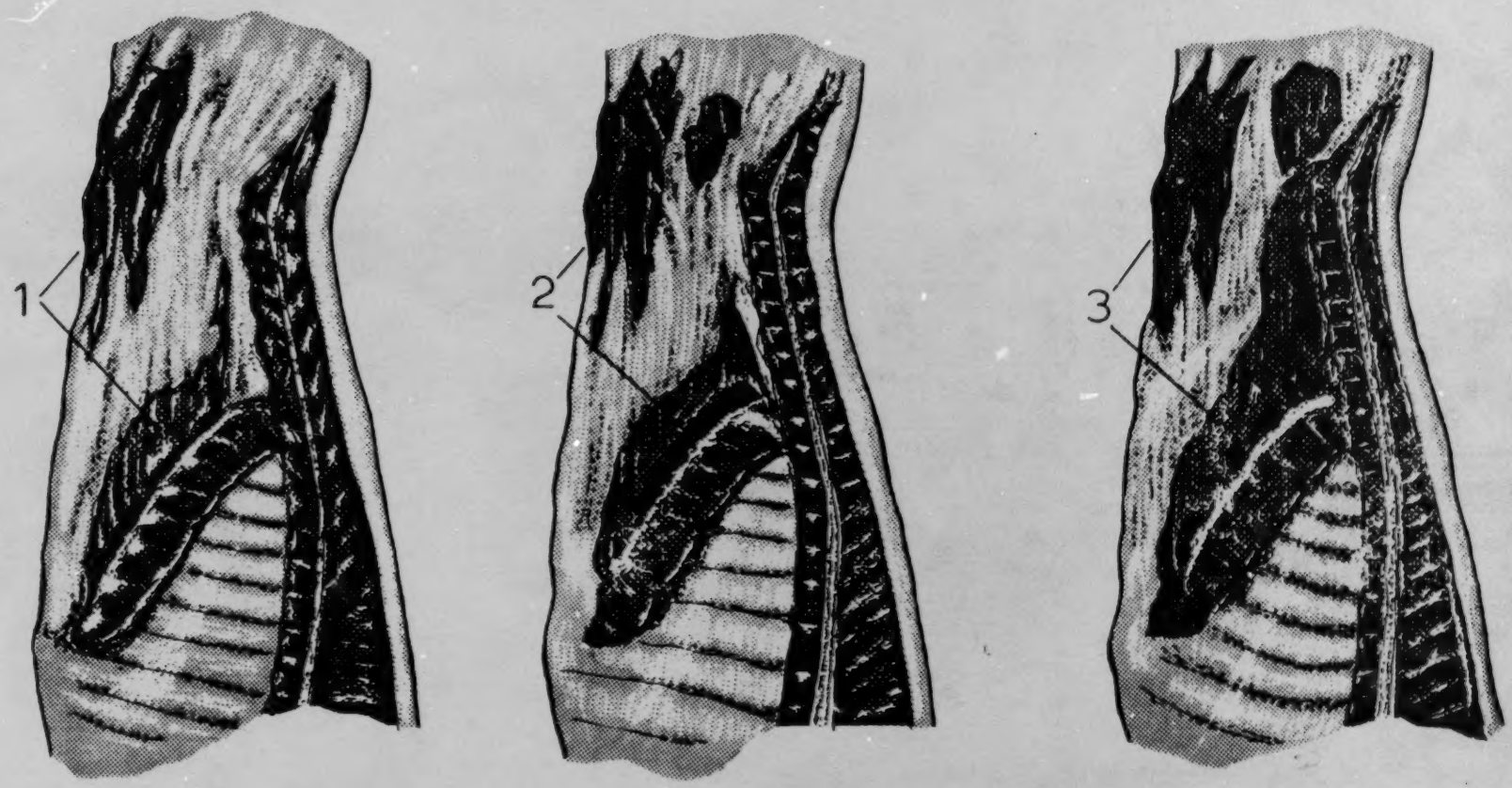
971

972

Ag II - XIV - 68

Ag II - XIV - 69

FLANK STREAKING IN LAMB CARCASSES



TM - 14b

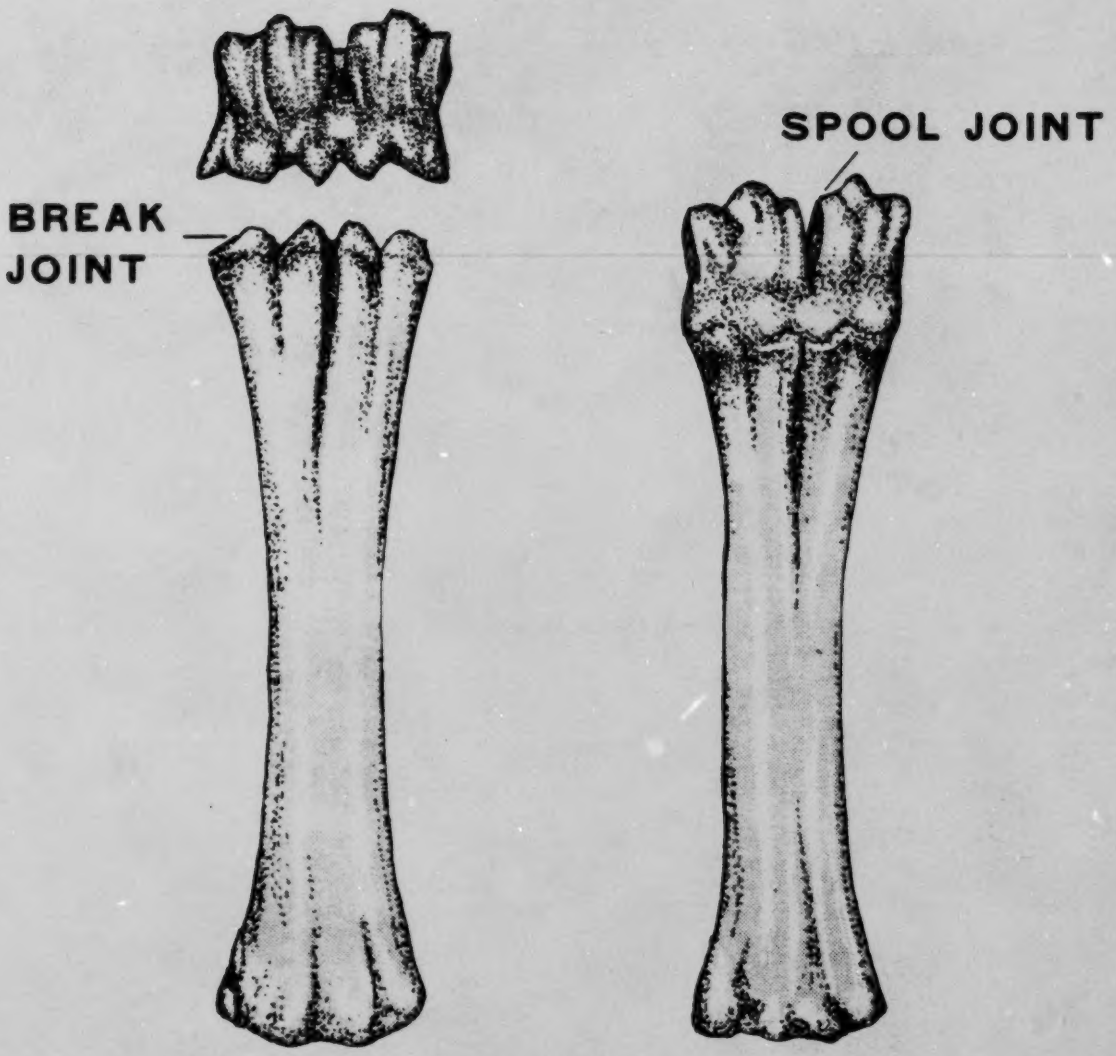
Minimum Requirements For Lambs

	PRIME	CHOICE	GOOD
FLANK STREAKING	1 Small	2 Traces	3 Practically None

973

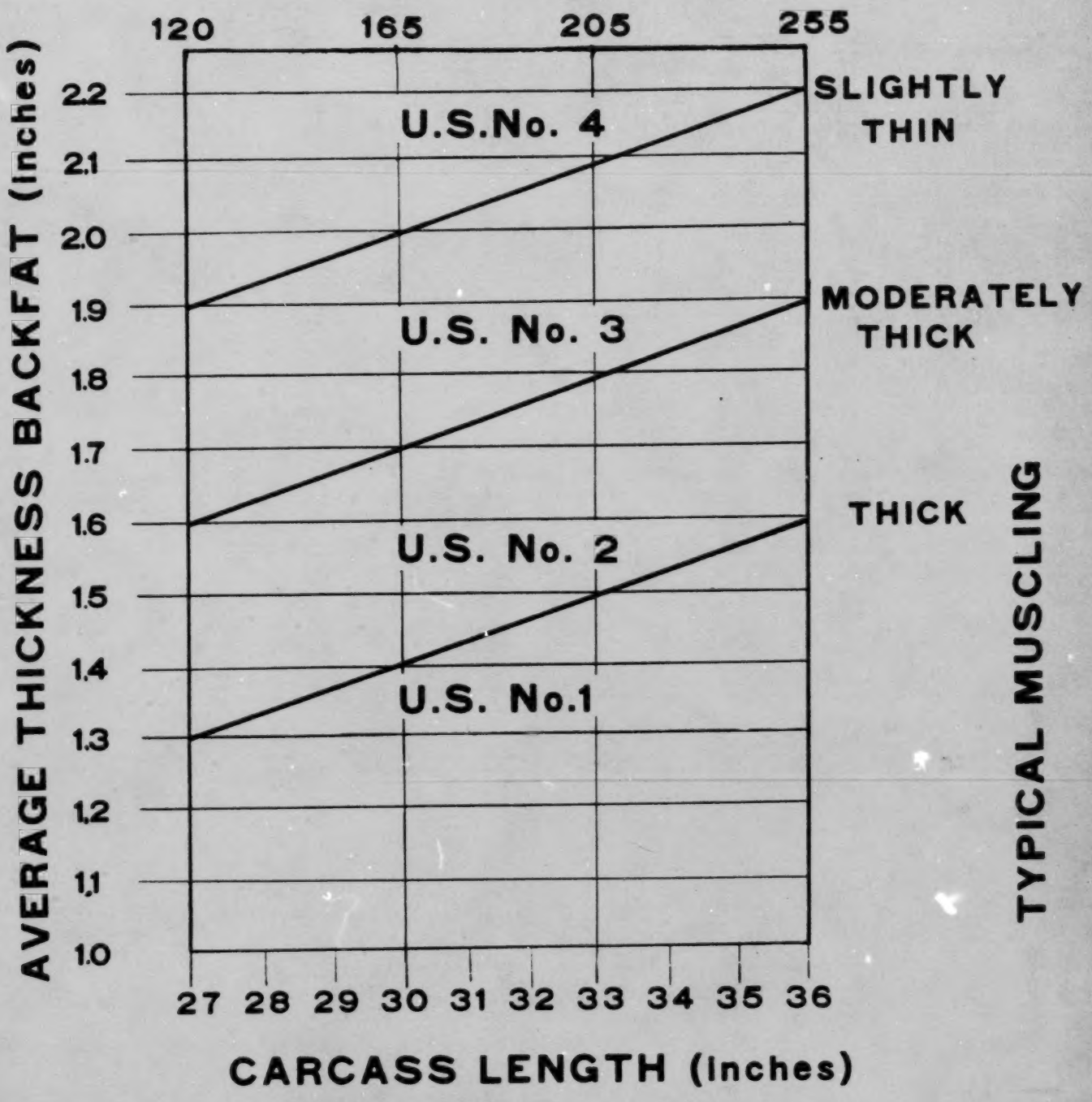
974

BREAK AND SPOOL JOINTS

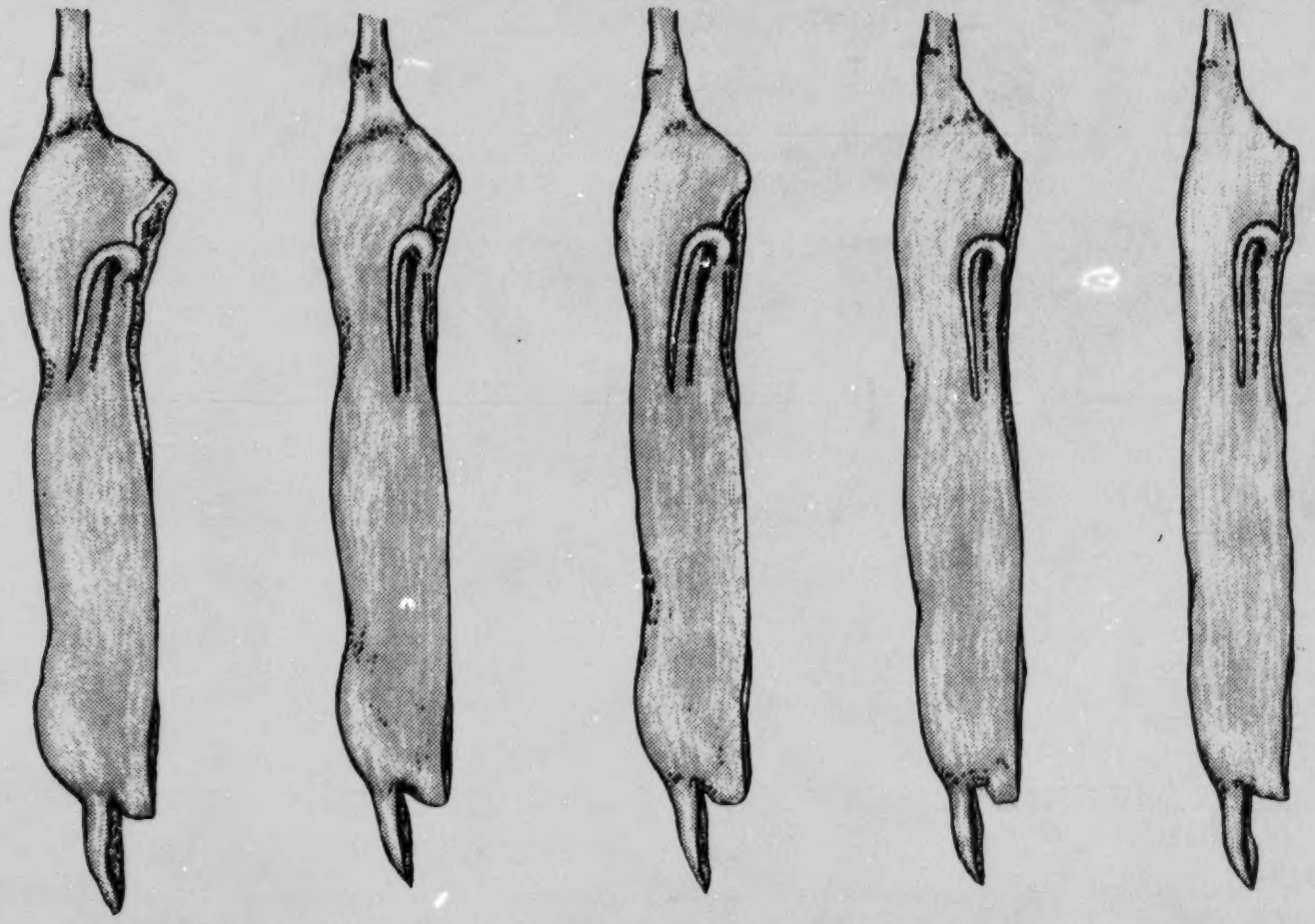


975

RELATIONSHIP BETWEEN BACKFAT THICKNESS, WEIGHT, AND LENGTH



DEGREES OF MUSCLING IN SWINE CARCASSES



VERY THICK | THICK | MODERATELY THICK | SLIGHTLY THICK | THIN

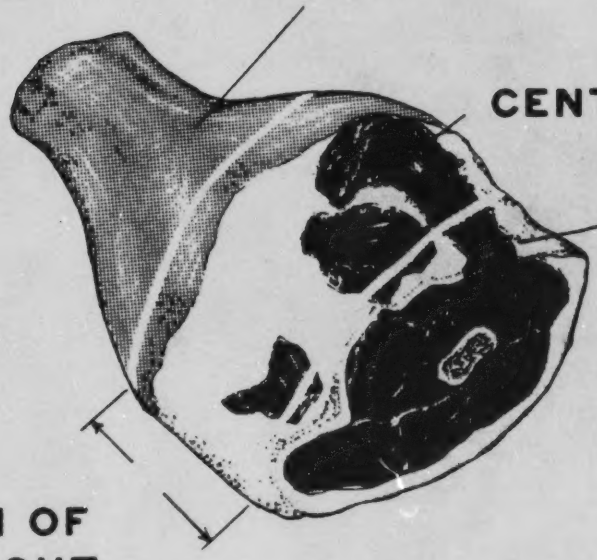
977

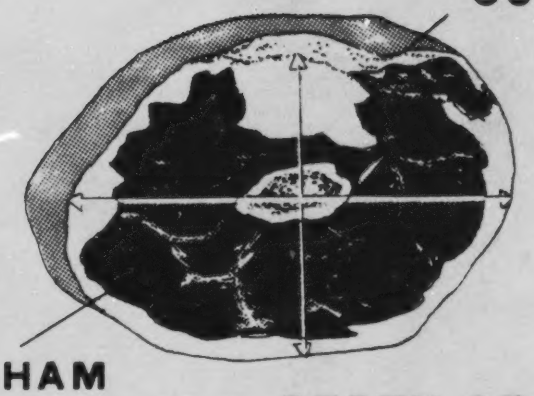
973

Ag II - XIV - 72

TM - 17

PARTS OF A HAM

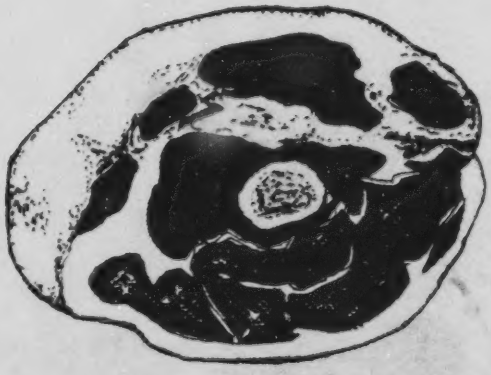




HAMS OF DIFFERENT QUALITY

(1)

(2)



(3)

(4)

ANIMAL SCIENCE

Topic 3: Poultry Judging and Poultry and Egg Grading

Terms: All terms underlined are found in the "Glossary of Terms".

Note: It is suggested that the students have access to "Poultry Grading Manual," Agriculture Handbook No. 31; "Egg Grading Manual," Agriculture Handbook No. 75; and an air cell depth gauge. These are available from the Consumer and Marketing Service, U.S. Department of Agriculture, Washington, D.C.

1. Judging Hens on Production

Hens in these classes at the State Poultry Judging Contest should be judged on present and past production, as they will have characteristics which will indicate both.

Transparency No. 1

To accurately judge the production classes, the student must be familiar with the five factors which affect production. The factors and the percent each factor influences the final placing are as follows: pigmentation, 40 percent; handling qualities, 25 percent; plumage condition, 20 percent; constitutional vigor and vitality, 10 percent; and the head and head parts, 5 percent.

Transparency No. 2

Pigmentation - The pigmentation is the yellow coloring in the skin and body of certain varieties of chickens. The fading of pigment is only an estimate and cannot be entirely accurate because factors such as body size, health of bird, makeup of feed, and amount of pigment when laying begins affects the rate in which pigment fades. When pullets begin to lay, their pigment fades in the following order: vent, 0 to 5 eggs; eyering, 4 to 8 eggs; earlobes (Leghorns only), 8 to 15 eggs; beak, 25 to 45 eggs (average 35 eggs); shanks, 150 to 250 eggs (average 180 eggs). The pigment of varieties other than those having yellow pigment should not be considered when judging hens for production.

A chicken with a beak that is completely bleached has been in production six to ten weeks and has laid approximately 35 eggs. The bleaching begins at the base of the beak and fades to the point. The first one-third of the beak fades after the bird has laid approximately 12 eggs. About twice as many eggs must be laid for two-thirds of the beak to become faded.

The shanks and toes are the last area to fade. The order in which the shanks and toes fade and the average number of eggs usually produced are bottom of feet, 70 eggs; front of shanks, 100 eggs; rear of shanks, 140 eggs; and top of toes and hocks joints, 180 eggs. A hen with bleached shanks has been in production from forty to fifty weeks.

After chickens stop laying, the pigment returns in the same order that it faded. The speed with which the pigment returns is governed by: (1) The amount of pigment in the feed, (2) Health and vitality of the hen, (3) Whether hens are confined

or on open range, and (4) Size and coarseness of hen.

Pigmentation is the single most important factor in judging birds for past production, and if possible, the class should be placed on this factor. If the birds have similar fading of pigmentation, then the next factor to consider is handling qualities. Other factors are considered in order of importance if birds cannot be placed on pigmentation and handling qualities.

Transparency No. 3

Handling Qualities - Handling quality and abdominal capacities are the two characteristics considered in this area. The size or amount of abdominal capacity is usually measured by fingers' width, such as 2 by 3 and 3 by 5. Condition is determined by the thinness and pliability of skin, thinness and flexibility of pelvic bones, softness of abdomen, and freeness from abdominal fat. Since the handling quality is a better indication of present production than past production, the placing of the birds in these classes should not be based entirely on handling quality.

The abdomen of a layer is expanded, should be three to four fingers wide between the pelvic bones and pelvic bones should be sharp. The pelvic bones of a non layer will be close together (1 finger's width); the abdomen will be hard, and the pelvic bones will be thick.

Plumage Condition - Two factors are considered in appraising the plumage condition of hens. First is the overall condition of the plumage. The feathers of a high producing hen will be dirty, frayed, ragged, and have a dull appearance. A hen of this type spends her time performing the functions associated with high production. In contrast, the feathers of a non layer will be smooth, show no wear and possess a great deal of sheen (shiny appearance).

The second consideration is the speed with which the birds molt. High producing hens molt during the fall and winter in eight to ten weeks, while low producers spend as much as 16 to 18 weeks and molt during the summer or early fall.

Chickens usually molt once a year; however, some chickens will molt twice a year and in rare cases once every two years. Hens usually discontinue laying while they are molting. The older of molt is head, neck, body, primaries, main tail, and secondaries.

Transparency No. 4

The rate a chicken molts is due to the rate in which they shed their feathers, rather than the rate of growth of new feathers. The chickens' wings can be examined to determine the rate of molting.

There are two groups of feathers in the wings of a hen - primary and secondary. The primary feathers molt from the axil feather (x) outward from 1 to 10 in order. The No. 1 illustration in transparency No. 4 shows the 10 old primary feathers. Illustration No. 2 shows the primary feathers of a slow molter

in the sixth-week of molt. There is one fully grown primary feather, and feathers number 2, 3 and 4 are developing at two-week intervals. In contrast is illustration No. 3, the faster molter, which has all new feathers. Feathers 1 - 3 were dropped first and are now fully developed. Feathers 4 - 7 were dropped next and now four weeks old, and feathers 8 - 10 were shed last and are two weeks old. Illustration No. 4 is the same as illustration No. 3 but is two weeks later with feathers 1 - 7 fully grown. The fast molters took ten weeks, and the slow molter took twenty-four weeks.

Constitutional Vigor and Vitality - To produce a large number of eggs over a long period of time, the hen must be healthy and vigorus. Vigor and vitality are indicated by a well-developed body; a healthy, vigorus bird will be alert, quick in her movements, and hard to catch. The hen must also consume and assimilate a large quantity of feed to be a high producer. She must be healthy to do this.

Head and Head Parts - Since only 5 percent of the final placing is based upon this area, very little attention should be paid to the head and head parts in judging production classes; however, a student should be able to recognize an ideal head and its parts. An ideal head will have a short, strong, slightly curved beak; and the eyes will be bright and have typical bright color. The skull should be flat from side to side; and the eyes should be in the front part of the head and high, near the skull. The comb and wattles should be large, velvety soft, and warm.

2. Judging Production Pullets

Each bird should be examined and observed individually. The birds must be caught to accomplish this. During the examination, the bird is held in the palm of one hand with the index finger placed between its legs; and pressure is applied by the thumb and forefinger next to the index finger to prevent the bird from getting loose. The head of the bird should face the judge. The other hand is free to examine the bird.

The production pullet class will be composed of pullets 18 - 22 weeks of age and raised under the same enviromental conditions. The principal factor considered in judging the bird is its potential production capacity as a layer. The selection of birds for future producers is an important factor in the success of a poultryrancher.

Transparency No. 5

Characteristics to consider are listed as follows:

Transparency No. 6

Body Conformation - A pullet having good conformation will have a deep, broad body and large heart girth. For the heart and lungs to function properly, the bird must have a large heart girth. It also is indicative of health, vigor, and longevity of production. The depth of body and width of the back behind the juncture of the wings and body are considered in evaluating heart and girth size.

Sexual Maturity - Sexual maturity should be expressed in the development of comb and head. Early sexual maturity should not be encouraged at the expense of growthiness and ruggedness in skeletal development. Size of development should be preferable to sexual maturity. For example, a rather small, poorly-developed pullet showed that advanced sexual maturity might possibly be placed down second or third in a class of well-developed pullets.

Head - The head should show the following characteristics: strong, moderately long, and well fitted in forward to the eyes to avoid any appearance of crowheadedness. The skull should be inclined to be somewhat flat on top rather than round. The face should be clean cut, smooth, and free from wrinkles; the skin should be of fine grain and soft in texture; the comb should be of good substance, size and of good color. The eye should be large, bright, and prominent; the iris should be rich in color; the pupil should be distinctly and perfectly formed.

The head is a good indicator of vitality. The eyes often indicate some form of systemic disease, particularly lucosis. A thin comb is indicative of a lack of vigor.

Feet and Toes - The pullet should be well balanced on her legs. The feet and toes should be normal.

Plumage Condition and Skin Color - Pullets should be fully feathered with plumage of good quality. Early full feathering is associated with broad, structurally firm feathers. The shanks should show a good healthy color. Emphasis should not be placed on intensity of color.

3. Grading Ready-To-Cook Broilers - Fryers, Roasters, and Turkeys

Two classes of ready-to-cook poultry are included in the poultry judging contest. One class is composed of ten broiler-fryers or roasters, while the other class has five turkey hens. An official grader must be able to determine the kind, class, condition, and quality of dressed poultry. This discussion includes those factors evaluated in grading broiler-fryers, roasters, and turkeys, since these are the classes in the poultry judging contest.

The student can become a competent grader much faster if they will follow a definite order of evaluating the carcasses each time they are graded. The grader should stand at about the same distance from the bird as is used for reading. The carcass should be turned so that the breast is facing the grader for the first evaluation.

The grades of broiler-fryers, roasters, and turkey hens are based upon carcass quality. The factors evaluated in grading dressed poultry are discussed in the order in which it is recommended that they be considered.

Fleshing - It is suggested that fleshing is considered first because it will be easier to evaluate the other factors. If a carcass has poor fleshing qualities (C Quality), then it is not necessary to evaluate the other factors.

Fleshing refers to the amount of meat on the carcass. The drumsticks, thighs, and breast contain most of the meat; however, there is a relationship between meat in these areas and the flesh over the back and the rest of the carcass. This relationship should become apparent after several carcasses of different quality have been graded. A fleshy carcass will have a full, rounded breast and meaty thighs and drumsticks. Evidences of a thinly fleshed carcass are V-shaped or concaved breast that tapers to the rear and thin legs and drumsticks.

Fat - Consumers are not in general agreement as to their preference for fat color. Some prefer a white or light, creamy colored fat, while others prefer a dark yellow fat. Fat is evaluated by determining the amount that has accumulated under the skin. Fat accumulates first around the feather follicles in the heavy feather tracts on the breast. As more fat is accumulated, it can be observed at the junction of the wishbone and keel and where the thin skin joins the breast skin. Another area to observe for fat is the heavy feather tracts over the back and hips. Broiler-fryers will have less fat than mature birds; however, it should be noticeable.

Conformation - The amount and distribution of fleshing is determined by carcass conformation.

Transparency No. 7

A quality bird will have a wide, long, full breast and meat thighs and drumsticks. Defects that may be found in inferior carcasses are dented, crooked knobby, V-shaped, or slab-sided breast; deformed legs and wings; and wedge shaped bodies.

Freedom From Pinfeathers - The presence of pinfeathers means that the consumer must spend additional time preparing the carcass for cooking. Pinfeathers are of two kinds, protruding and non-protruding. Protruding pinfeathers are those which have broken through the skin and may or may not have formed a brush. Non-protruding pinfeathers are those that can be observed but have not pushed through the outer layer of the skin. Ready-to-cook poultry must be free of pinfeathers before it can be graded. The term "free from pinfeathers" means that as the carcass travels at a normal speed through the processing line it was free from visible pinfeathers. An occasional pinfeather may be observed on carcasses that make up a class of ready-to-cook poultry and be considered free.

Freedom From Exposed Flesh Resulting From Cuts, Tears, and Broken Bones -

Exposed flesh caused by cuts, tears, missing skin, and broken or disjointed bones detracts from the appearance and lowers carcass quality. Tears and missing skin permit the flesh to dry out during cooking, and broken and disjointed bones often cause bruises and blood clots. The number and extent of defects permitted depend on the location of the defect(s).

Freedom From Discolorations of Skin and From Flesh Blemishes and Bruises -

Injury during processing and handling are the usual causes of discolorations. Skin abrasion is the most common cause. After the skin has been injured, is exposed to the air, and dries out, a discoloration appears.

Freezing defects are not discussed because frozen carcasses are not used in the contest. A discussion of broken and disjointed bones is included in the above. Missing parts are covered in the standard, which is included in this topic.

After an evaluation of the above factors has been completed, a final grade must be given to the carcass. The final grade will be based on the factor receiving the lowest grade. A carcass meeting the requirements for A Quality in all except one factor and appraised as a B Quality for that factor would receive a B Quality grade. The tolerance in each quality grade for each defect is the maximum permitted.

Transparency No. 8

Transparency No. 8 may be used as a guide in estimating the size of an area having exposed flesh and discoloration.

Grading Card

STUDENT'S NAME _____ DATE _____

Bird No.	Fleshing		Fat Covering		Conformation		Pinfeathers		Cuts, tears, and broken bones		Bruises and Discoloration		Final Grade	
	Student	Instructor	Student	Instructor	Student	Instructor	Student	Instructor	Student	Instructor	Student	Instructor	Student	Instructor
1														
2														

The use of this grading card may help the student in establishing an order of observing the different factors considered in grading.

SUMMARY OF SPECIFICATIONS FOR STANDARDS OF QUALITY
INDIVIDUAL CARCASSES OF READY-TO-COOK POULTRY

(Minimum Requirements and Maximum Defects Permitted)

Factor	A Quality	B Quality	C Quality
CONFORMATION:			
Breastbone	Normal Slight curve or dent	Moderate deformities Moderately dented, curved, or crooked	Abnormal Seriously curved or crooked.
Back	Normal (Except slight curve)	Moderately crooked	Seriously crooked
Legs and wings	Normal	Moderately misshapen	Misshapen
FLESHING:	Well fleshed, moderately long, deep, and rounded breast	Moderately fleshed, considering kind, class, and part	Poorly fleshed
FAT COVERING:	Well covered, especially between heavy feather tracts on breast and considering kind, class, and part	Sufficient fat on breast and legs to prevent distinct appearance of flesh through the skin	Lacking in fat covering over all parts of carcass
PINFEATHERS:			
Nonprotruding pins and hair	Free	Few scattered	Scattering
Protruding pins	Free	Free	Free
EXPOSED FLESH:[1]	Breast and Legs	Breast[2] and Legs	No Limit
Carcass Weight			
Over 1 1/2 - 6 lbs.	None 1 1/2"	1 1/2" 3"	
DISCOLORATIONS:[3]			
Over 1 1/2 - 6 lbs.	1" 2"	2" 3"	No Limit[4]
Disjointed bones	1	2 disjointed and no broken or 1 disjointed and 1 non-protruding broken wing tips, 2nd wing joint and tail	No Limit
Broken bones	None		No Limit
Missing parts	Wing tips and tail[5]		Wing tips, wings and tail

[1]Total aggregate area of flesh exposed by all cuts, tears, and missing skin. [2]A carcass meeting the requirements of A quality for fleshing may be trimmed to remove skin and flesh defects, provided that not more than 1/3 of the flesh is exposed on any part and the meat yeild is not appreciably affected. [3]Flesh bruises and discolorations such as "blue back" are not permitted on breast and legs of A quality birds. Not more than 1/2 of total aggregate area of discolorations may be due to flesh bruises or "blue back" (when permitted) and skin bruises in any combination. [4]No limit on size and number of areas of discoloration and flesh bruises if such areas do not render any part of the carcass unfit for food.

The above transparency may be used as a guide in estimating the size of an area having exposed flesh and discolorations.

4. Grading Eggs on Exterior Quality

Automatic equipment and mass scanning devices have practically replaced the hand candling of eggs by commercial producers. Both exterior and interior quality factors are considered simultaneously when commercially grading eggs. To facilitate the teaching of egg quality to students, separate classes have been established for poultry judging contests.

Exterior quality eggs are determined by evaluating the (1) shell shape and texture, (2) shell soundness, and (3) shell cleanliness. An explanation of each of the three considerations is provided.

Transparency No. 9

Shell shape and texture - The normal egg has an oval shape with one end larger than the other, and it tapers toward the smaller end. The ends of an egg are commonly referred to as the large end (air cell end) and the small end. Measurements of both strength and appearance of many eggs by investigators resulted in the development of the "ideal" egg shape.

The shape of an egg can be considerably different from the "ideal" but may still be considered practically normal. The grader must keep in mind a metal picture of the normal or usual shape of an egg and compare each egg as they grade it with the picture.

Eggs that are unusual in shape, such as those having ridges, rough areas, or thin spots, are placed in the lower grades. Depending upon the extent and severity of the ridge, these eggs may be classed as B quality or C quality.

The specifications of the United States Standards provide three degrees of variation:

Practically normal - A shell that approximates the usual shape and that is of good even texture and strength and free from rough areas or thin spots. Slight ridges and rough areas that do not materially affect the shape, texture, and strength of the shell are permitted. (AA and A Quality.)

Slightly abnormal - A shell that may be somewhat unusual in shape or that may be slightly faulty in texture and or strength. It may show definite ridges but no pronounced thin spots or rough areas. (B Quality.)

Abnormal - A shell that may be decidedly misshapen or faulty in texure or strength or that may show pronounced ridges, thin spots, or rough areas. (C Quality.)

Soundness of Shell - Eggs in this class are not handled by the student; therefore, cracks in the eggs should be ignored. The shell of an egg may be sound, checked or cracked, leaking, or smashed. Checks may range from a very fine hairlike check (blind check) that is discernible only before a candling light to those that are noticeable on sight.

Belling is often used by commercial graders when they suspect a blind check. Of course, leakers and smashed eggs would be removed from the lot by commercial graders.

Shell Cleanliness - Freedom from stains and foreign materials on the shell of eggs must be considered in assigning a quality designation to an individual egg. The following terms are descriptive of shell cleanliness:

Clean - A clean shell is free from foreign material and from stains or discolorations that are readily visible. An egg may be considered clean if it has only very small specks or stains, if such specks or stains are not of sufficient number or intensity to detract from the generally clean appearance of the egg. Eggs that show traces of processing oil on the shell are considered clean unless otherwise soiled. (AA and A Quality.)

Sligtly stained - A shell in this classification is free from adhering dirt, but may have slight stains which do not appreciably detract from the appearance of the egg. When the stain is localized, approximately 1/32 of the shell surface may be slightly stained, and when the stained areas are scattered, approximately 1/16 of the shell surface may be slightly stained. (B Quality.)

Eggs having more than 1/16 of the shell surface slightly stained may be classified as C Quality.

Moderate stains - A shell that is free from adhering dirt, but which has stains of a moderate degree covering not more than 1/4 of the shell surface. (C Quality.)

Dirty - The shell must be unbroken with adhering dirt, foreign material, prominent stains, or moderate stains covering more than 1/4 of the shell surface.

Transparency No. 10

It is difficult to compare the aggregate soiled area with the standards. However, if the grader keeps in mind that the total area of a normal 2-ounce egg is about 10 1/2 square inches. 1/32 of the shell surface of a 2-ounce egg would measure approximately 3/8"; 1/16 would measure about 13/16" x 13/16"; and 1/4 of the shell surface would measure a little more than 1 1/2" x 1 1/2".

The proper position for grading eggs in this class is to stand directly in front of the egg and view it from eye level. The official grade will be determined from this distance in poultry judging contests. It is not necessary for the grader to observe that portion of the egg that cannot be seen in this position.

Shell color is not a factor in grading eggs; although, some consumers have a preference for different egg colors. Usually the preference is based on the belief that a color has superior quality or more food value, but there is not basis for these opinions.

SUMMARY OF UNITED STATES STANDARDS FOR QUALITY OF INDIVIDUAL SHELL EGGS

Quality Factor	AA Quality	A Quality	B Quality	C Quality
Shell	Clean. Unbroken. Practically Normal.	Clean. Unbroken. Practically Normal.	Clean; to very slightly stained. Unbroken. May be slightly abnormal.	Clean; to moderately stained. Unbroken. May be abnormal.
Air Cell	1/8 inch or less in depth. May show unlimited movement and may be free or bubbly.	3/16 inch or less in depth. May show unlimited movement and may be free or bubbly.	3/8 inch or less in depth. May show unlimited movements and may be free or bubbly.	May be over 3/8 inch in depth. May show unlimited movement and may be free or bubbly.
White	Clear. Firm. (72 Haugh units or higher.)	Clear. May be reasonably firm. (60 to 72 Haugh units.)	Clear. May be slightly weak. (31 to 60 Haugh units.)	May be weak and watery. Small blood clots or spots may be present.* (Less than 31 Haugh units.)
Yolk	Outline slightly defined. Practically free from defects.	Outline may be fairly well defined. Practically free from defects.	Outline may be well defined. May be slightly enlarged and flattened. May show definite but not serious defects.	Outline may be plainly visible. May be enlarged and flattened. May show clearly visible germ development but no blood. May show other serious defects.

* If they are small (aggregate not more than 1/8 inch in diameter).

For eggs with dirty or broken shells, the standards of quality provide three additional qualities:

Dirty	Check	Leaker
Unbroken. May be dirty.	Checked or cracked but not leaking	Broken so contents are leaking

5. Grading Eggs on Interior Quality

Prior to using the candles for grading eggs, the student should learn the U.S. Standards for Quality of Individual Shell Eggs.

In order to determine interior quality, eggs must be candled. The egg to be candled is held between the thumb and index finger, and the small end of the egg sets agaist the second finger. The contents of the egg are set in motion by a movement of the hand and wrist in an arc of about 180 degrees. Stopping the hand motion at the end of the arc without moving the arm or body permits the contents to spin within the shell. The long axis of the egg should be at about a 45 degree angle to the candling aperture.

Transparency No. 11

The interior quality of eggs deteriorate from the time they are laid until they are consumed. The decline of quality can be minimized by properly caring for eggs.

Eggs having characteristics which place them in the center of a grade are relatively easy to grade. It is more difficult to grade eggs with characteristics which place them on the border line between two grades. In order to understand the factors considered in grading eggs for interior quality, the student must know the parts of an egg.

It is generally easier for the student to grade eggs if he considers each quality factor (air cell, yolk condition, and condition of whits) separately. After each factor has been considered, the student should consider the combination of factors. However, the grade of the egg will be the lowest grade an egg would receive in any one factor. An explanation of each factor follows:

Transparency No. 12

Air cell - The air cell is the easiest factor to evaluate by the student. An aircell guage (a card cut the shape of an egg with the different air-cell depths designated) should be used by the student the first few times they candle eggs. This will help them in estimating the depth of the air cell. The following terms are descriptive of the air cell.

Depth of air cell - This if the air space between shell membranes and is normally in the large end of the egg. The depth of the air cell us the distance from its top to its bottom when the egg is held air cell up ward.

Free air cell - An air cell that moves freely toward the uppermost point in the egg is rotated slowly. The shell membranes are intact, but the air cell moves freely in any direction between them.

Bubbly air cell - A ruptured air cell resulting in one or more small separate air bubbles usually floating beneath the main air cell.

Yolk Condition - Yolk quality is determined by the shadow it

casts upon the shell before the candling light; however, the appearance of the yolk is dependent upon the condition of the albumen. The three factors to consider in judging yolk quality are distinctness of yolk shadow outline, size and shape of yolk, and defects and germ development.

The distinctness of the yolk shadow outline is governed by the following:

(1) Thickness and consistency of albumen - The thicker the albumen the less distinct the outline appears, because the yolk is prevented from moving close to the shell.

(2) Condition of yolk - The condition is determined by the presence of blemishes that show up before the candling light as dark shadows in the yolk, or the absence of these blemishes; and the presence or absence of an off-colored yolk appearance which shows as a grayish or greenish shadow.

(3) Color of yolk - It is difficult to determine the color of the yolk under the candle light, except off-color.

The four degrees of distinctness of yolk shadow outlines are as follows:

Outline slightly defined - A yolk outline that is indistinctly indicated and appears to blend into the surrounding white as the egg is twirled (AA Quality).

Outline fairly well defined - A yolk outline that is discernible but not clearly outlined as the egg is twirled (A Quality).

Outline well defined - A yolk outline that is quite definite and distinct as the egg is twirled (B Quality).

Outline plainly visible - A yolk outline that is clearly visible as a dark shadow as the egg is twirled (C Quality).

Size and Shape of Yolk - Yolk size and shape are considered in the B and C quality grades. As the yolk ages, it absorbs water from the albumen which increases its size and causes it to stretch and weaken the vitelline membrane and become flat in shape and "out of round".

A slightly enlarged and slightly flattened (B Quality) yolk is one with a weak membrane and tissue. An enlarged and flattened yolk (C Quality) is one in which the yolk has absorbed moisture from the white to such an extent that it appears definitely enlarged and flat.

Defects and Germ Development - Little is known about the causes of yolk defects other than those due to germ development. Germ development is visible before the candling light and can generally be detected as a circular dark area near the center of the yolk shadow. If blood is visible, the egg must be rejected as inedible.

The following terms describe yolk defects:

Practically free from defects - A yolk that shows no germ development, but it may show other very slight defects on its surface. (AA or A Quality.)

Definite but not serious defects - A yolk that may show definite spots or areas on its surface but only slight indications of germ development or other pronounced or serious defects. (B Quality.)

Other serious defects - A yolk that shows well-developed spots or areas and other serious defects, such as an olive yolk, which do not render egg inedible. (C Quality.)

Clearly visible germ development - Development of the germ spot on the yolk of a fertile egg that has progressed to the point where it is plainly visible as a circular area or spot with no blood in evidence. (C Quality.)

Blood due to germ development - Blood caused by development of the germ in a fertile egg to a point where it is visible as definite lines or a blood ring. Such an egg is classified as inedible.

Condition of White - The condition of the white is determined in candling by the intensity of the yolk shadow and the freedom of movement of the yolk as the egg is twirled before the candling light. The viscosity of the white is related to these factors. A thick white permits only limited movement of the yolk and an indistinct shadow, and a thin white permits free movement of the yolk and a distinct shadow. The following terms are descriptive of the white:

Clear - A white that is free from discolorations or from any foreign bodies floating in it. A prominent chalaza should not be confused with foreign bodies such as spots or blood clots. (AA, A, B Quality.)

Firm - A white that is sufficiently thick or viscous to prevent the yolk outline from being more than slightly defined or indistinctly indicated when the egg is twirled. With respect to a broken-out egg, a firm white has a Haugh unit value of 72 or higher when measured at a temperature between 45° and 60° F.

Reasonably firm - A white that is somewhat less thick or viscous than a firm white. A reasonably firm white permits the yolk to approach the shell more closely which results in a fairly well defined yolk outline when the egg is twirled. With respect to a broken-out egg, a slightly weak white has a Haugh unit value of 31 to 60 when measured at a temperature between 45° to 60° F.

Slightly weak - A white that is lacking in thickness or viscosity to an extent that causes the yolk outline to appear well defined when the egg is twirled. With respect to a broken-out egg, a slightly weak white has a Haugh unit value of 31 to 60 when measured at a temperature between 45° to 60° F.

Weak and watery - A white that is thin and generally lacking in viscosity. A weak and watery white permits the yolk to approach the shell closely, thus causing the yolk outline to appear plainly visible and dark when the egg is twirled. With respect to a broken-out egg, a weak and watery white has a Haugh unit value lower than 31 when measured at a temperature between 45° to 60° F.

Blood clots and spots (not due to germ development) - Blood clots or spots commonly called meat spots may be found on the surface of the yolk or floating in the white. If they are small (aggregating not more than 1/8 inch in diameter) the egg may be classed a "C Quality". If larger or showing diffusion of blood in the white surrounding them, the egg shall be classified as loss.

Bloody white - An egg white which has blood diffused through it. Such a condition may be present in newly laid eggs. Eggs with bloody whites are classed as loss.

Inedible eggs - Eggs of the following descriptions are classed as inedible: black rots, white rots, mixed rots, sour eggs, eggs with green white, eggs with stuck yolks, moldy eggs, musty eggs, eggs showing blood rings, eggs containing embryo chicks (at or beyond the blood ring stage), and any eggs that are adulterated as such is defined pursuant to the Federal Food, Drug, and Cosmetic Act.

6. Determining Interior Quality by the Break-out Method

Extensive research has been conducted for a number of years for the purpose of developing a more objective method of determining interior egg quality based on the measurement of the height of the thick albumen correlated with the weight of the egg. It has been determined from statistical analysis that a small sample of eggs randomly selected from a flock of chickens composed of birds near the same age and managed under similar conditions is highly accurate in reflecting the average quality of the lot.

As a result of the research in this area, in 1959 the U.S.D.A. implemented a Quality Control Program which made possible the marketing of high quality eggs from controlled flocks under the Fresh, Fancy, or AA label of identification. A similar program, having less stringent requirements, was initiated for marketing Grade A eggs.

The Haugh unit reading (see Glossary of Terms) is the most important factor in determining interior quality by the break-out method. However, yolk quality must be considered as a secondary factor. The yolks in the sample must have a uniform color in order for the flock to remain in the quality control program. Other requirements are also specific for remaining in the program.

The inclusion of break-out eggs in the FFA Poultry Judging Contest is probably the result of the Quality Control Program. Students should become familiar with the grades of break-

out eggs, which are shown in transparency No. 13.

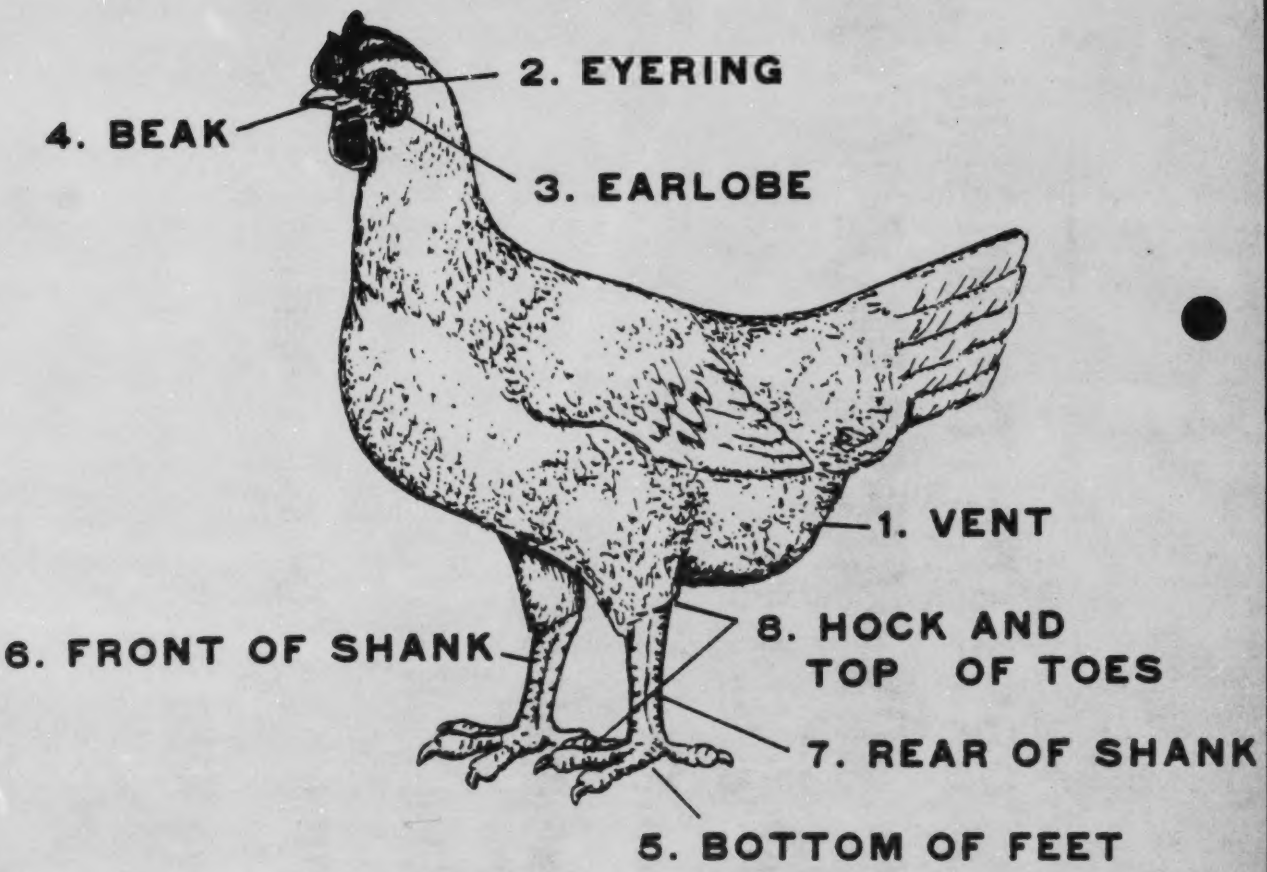
Transparency No. 13

Note: Much of the information for this topic was taken from the "Poultry Grading Manual," Agriculture Handbook No. 31, and "Egg Grading Manual," Agriculture Handbook No. 75. Both are USDA publications.

SCORE CARD FOR JUDGING HENS FOR RATE OF PRODUCTION

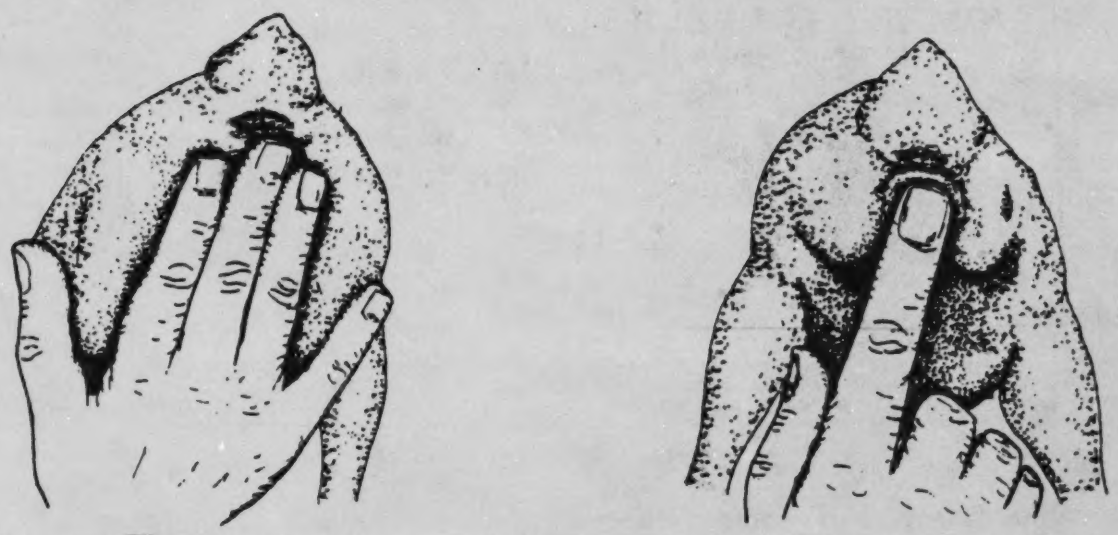
CHARACTERISTICS	PERCENT EMPHASIS
PIGMENTATION	40%
HANDLING QUALITIES	25%
PLUMAGE CONDITION	20%
CONSTITUTIONAL VIGOR AND VITALITY	10%
HEAD AND HEAD PARTS	5%
	100%

THE ORDER PIGMENT FADES

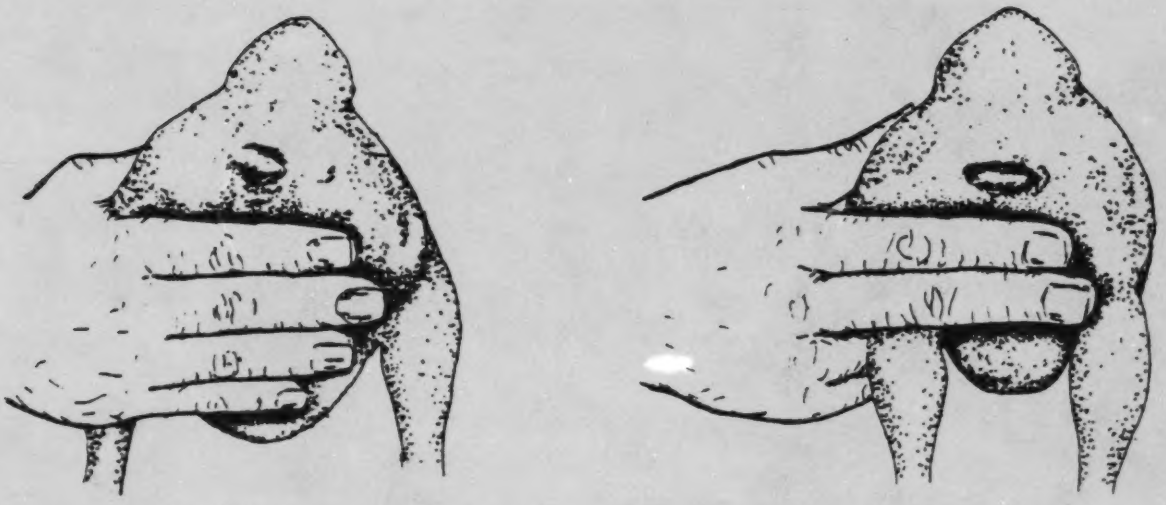


1000

HANDLING QUALITIES OF LAYING HENS

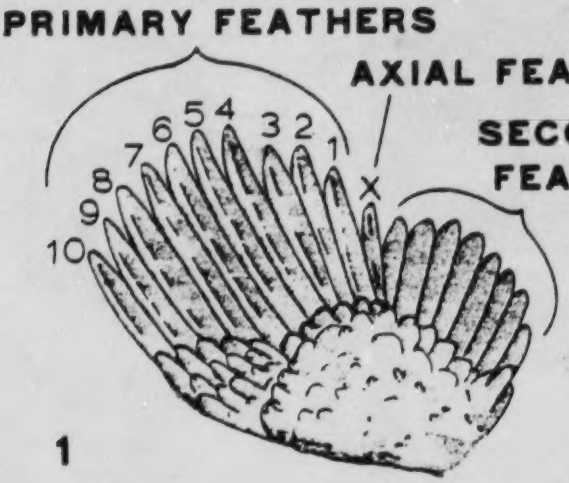


The Distance Between the Ends of the Pelvic or Pubic Bones in a Laying Hen (left); in a Non—Laying Hen (right)



The Distance Between the Ends of the Pubic Bones and the Keel Bones is Greater in the Layer (left) Than in the Non—Layer (right)

WING FEATHERS IN DIFFERENT STAGES OF GROWTH



1

SHOWS THE 10 OLD PRIMARY FEATHERS. THE SECONDARY FEATHERS ARE SEPARATED BY THE AXIAL FEATHER (X)

2

SHOWS A SLOW MOLTER AT SIX WEEKS OF MOLT, WITH ONE FULLY GROWN PRIMARY FEATHER AND FEATHERS 2, 3, AND 4 DEVELOPING AT TWO WEEK INTERVALS.

3

A FAST MOLTER HAS ALL NEW FEATHERS. FEATHERS 1 TO 3 WERE DROPPED FIRST, FEATHERS 4 TO 7 DROPPED NEXT, AND FEATHERS 8 TO 10 WERE DROPPED LAST.

4

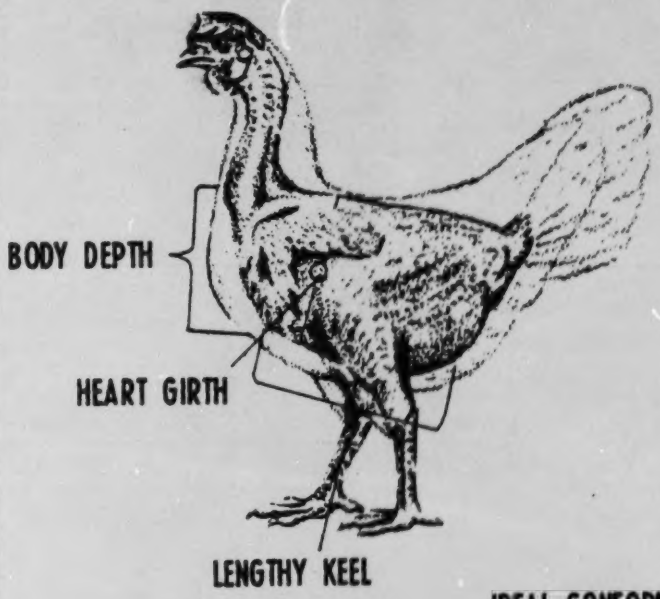
TWO WEEKS LATER FEATHERS 1 TO 7 ARE FULLY GROWN. THE FAST MOLT TOOK 10 WEEKS AS COMPARED TO 24 WEEKS FOR THE SLOW MOLT.

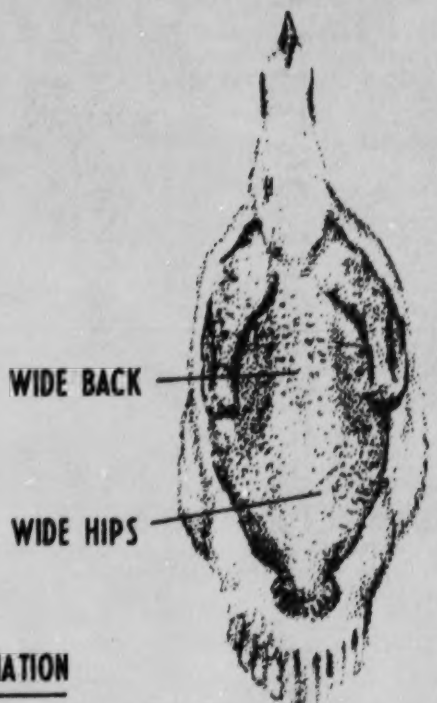
10 12

SCORE CARD FOR JUDGING BROILER BREEDER FEMALES

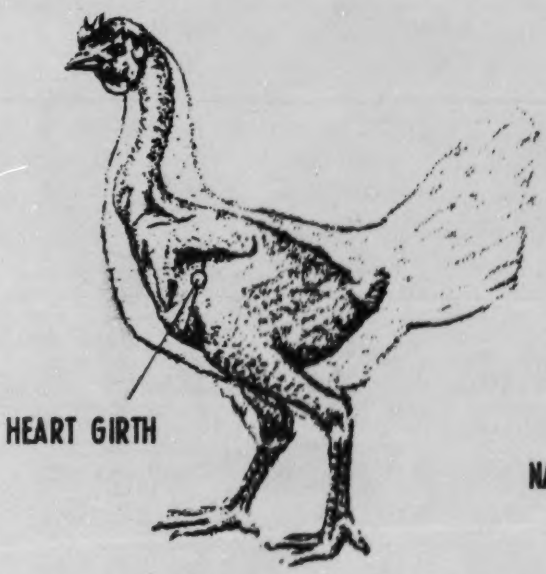
CHARACTERISTICS AND QUALITIES	PERCENT EMPHASIS
1. head	5
2. back	10
3. breast	40
4. legs, thighs and shanks	20
5. feet and toes	5
6. neck (wry or crooked — cull)	0
7. wings	5
8. condition, vigor and plumage	15
TOTAL	100

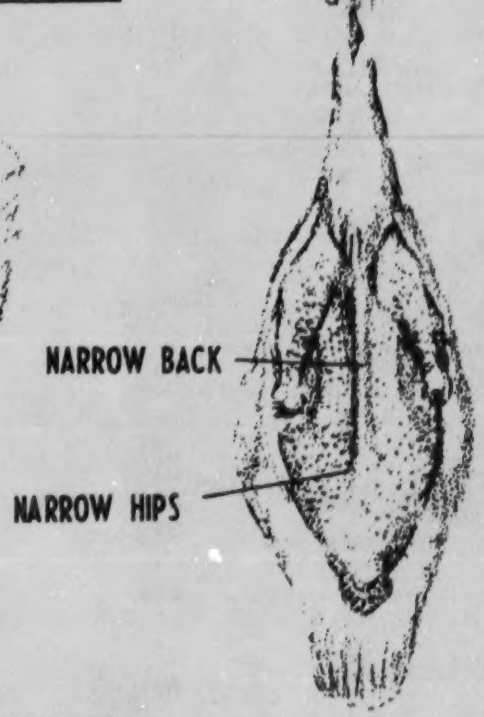
PULLET BODY CONFORMATION





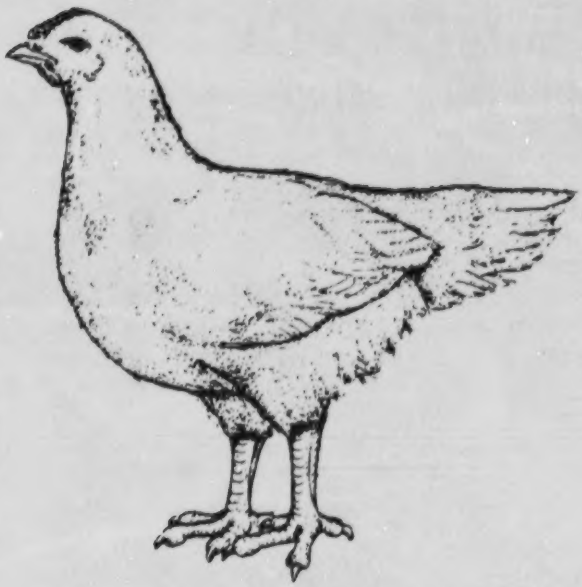
IDEAL CONFORMATION



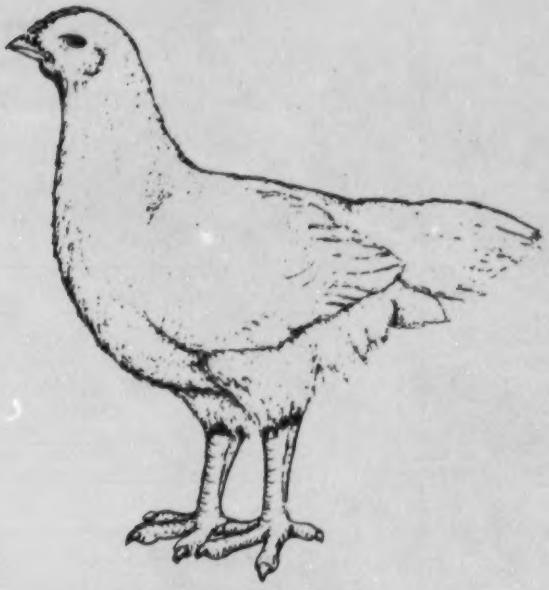


POOR CONFORMATION

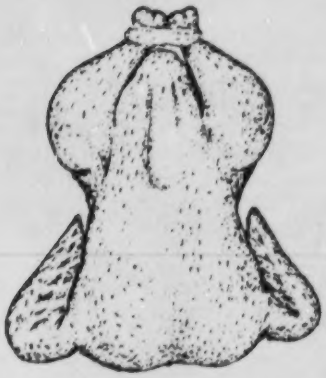
BROILER CONFORMATION



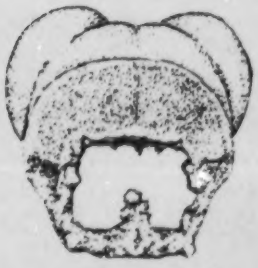
DESIRABLE



UNDESIRABLE

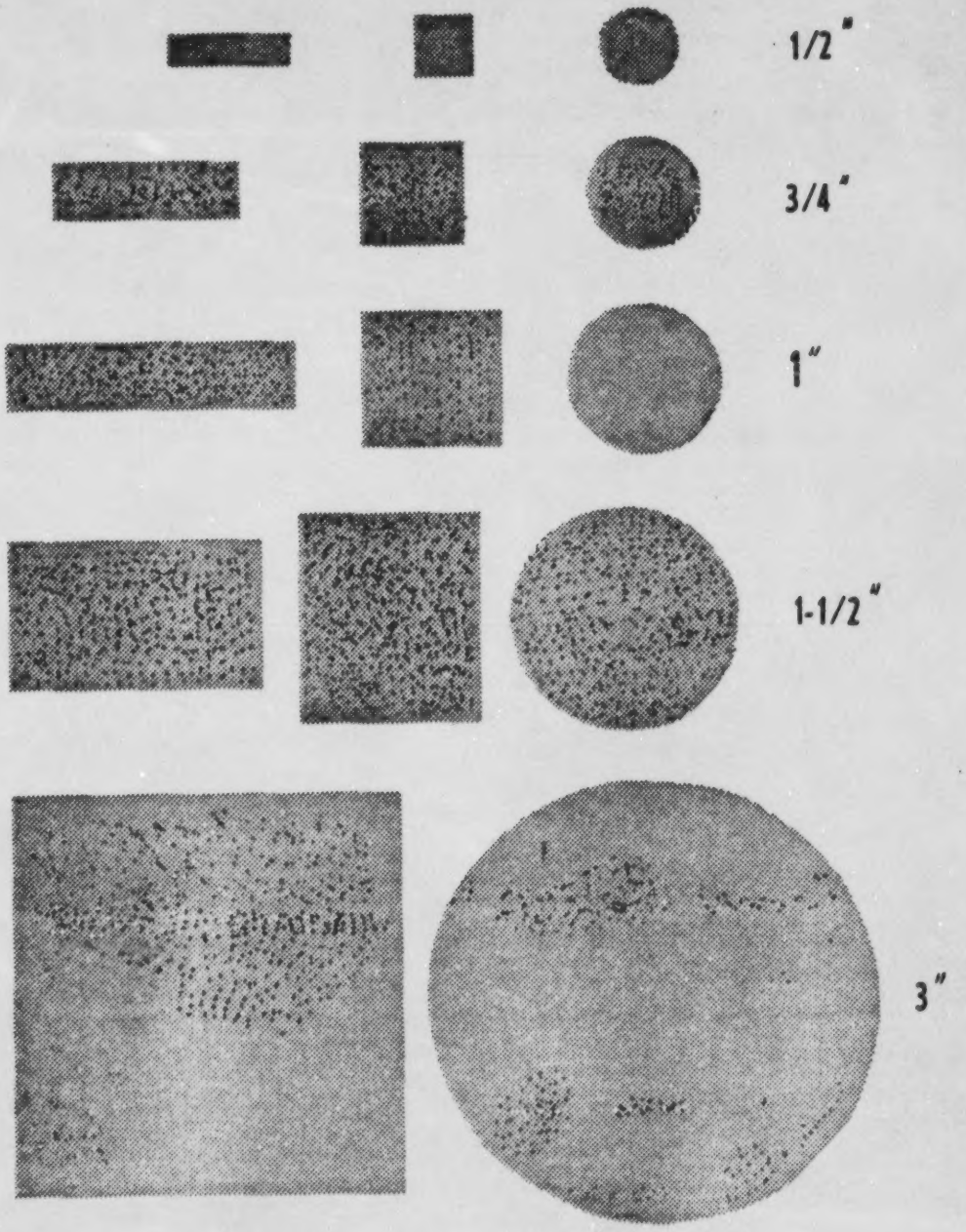


DRESSED CARCASS



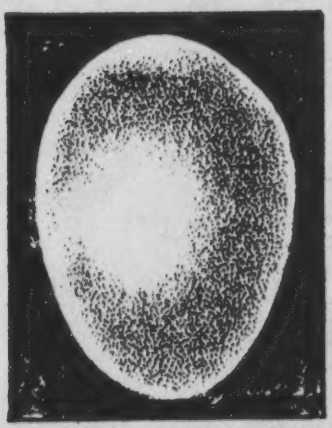
CROSS SECTION OF BREAST

GUIDE FOR ESTIMATING THE RELATIVE SIZE OF DISCOLORATIONS

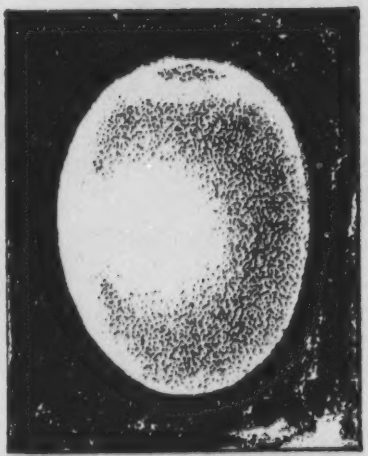


SHELL SHAPES

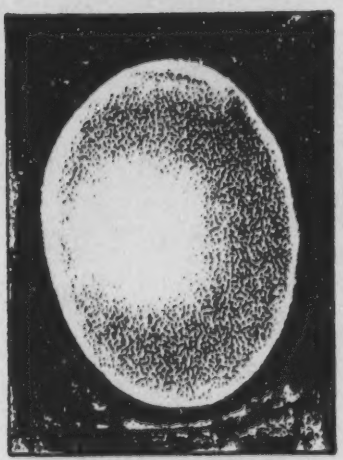
IDEAL EGG SHAPE



PRACTICALLY NORMAL SHAPE
AA or A QUALITY



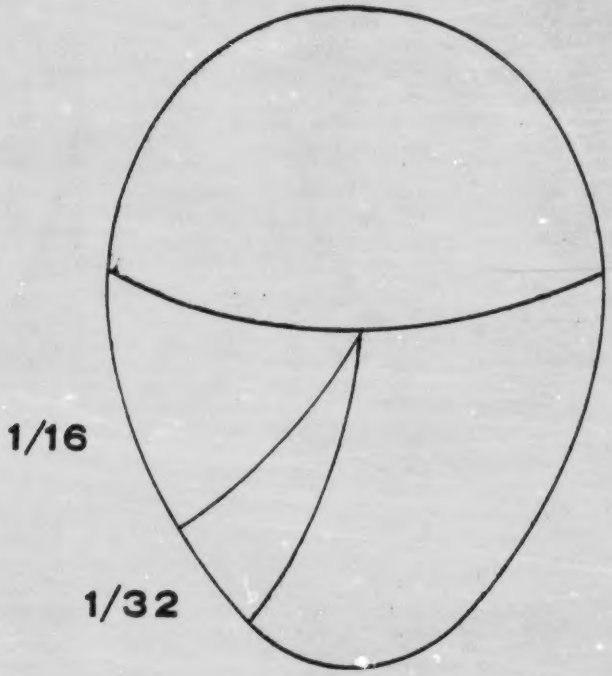
SLIGHTLY ABNORMAL SHAPE
B QUALITY



ABNORMAL SHAPE
C QUALITY

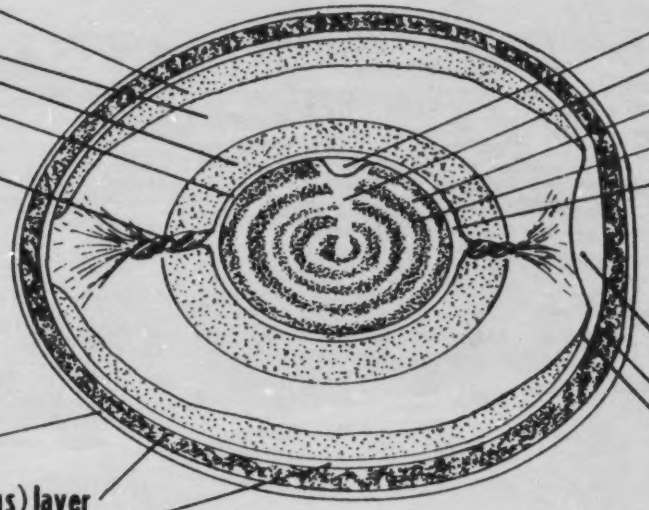
AN EGG SHOWING THE ACTUAL SIZE OF STAIN AND DIRT

1/4 of shell surface of an egg(one side)



1/32, 1/16, and 1/4 of shell surface of an egg

PARTS OF AN EGG



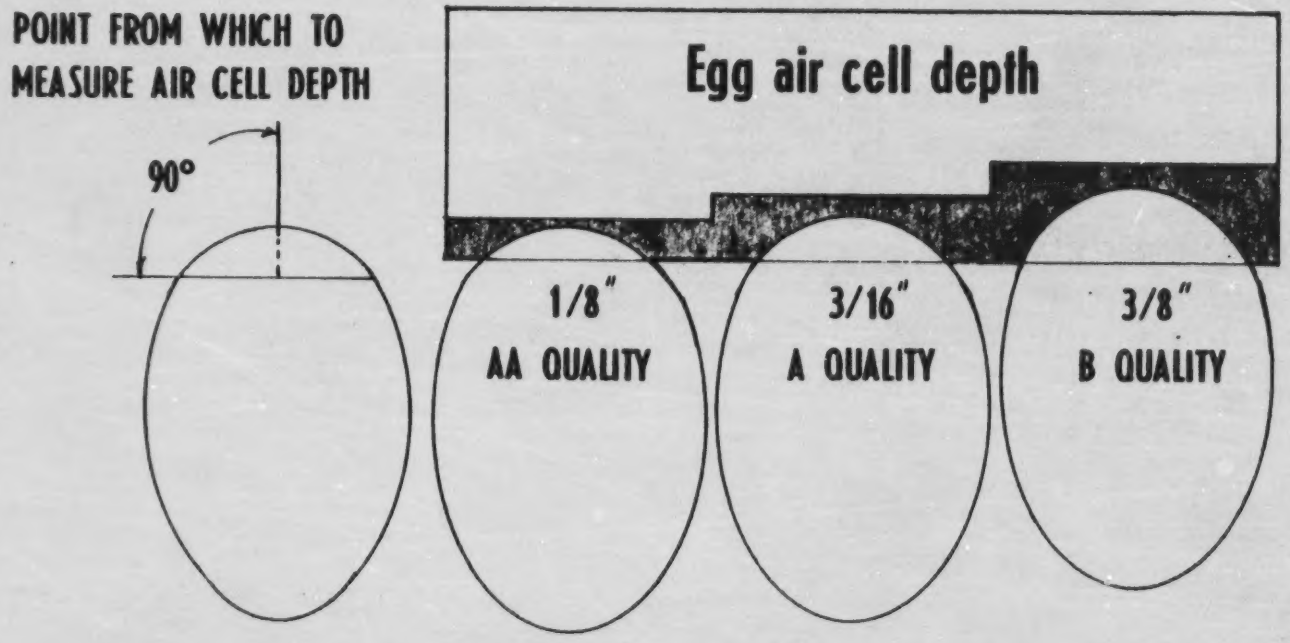
ALBUMEN
- outer thin
- firm
- inner thin
- chalaziferous
- chalazae

YOLK
- germinal disc
- latebra
- light yolk layer
- dark yolk layer
- yolk (vitelline) membrane

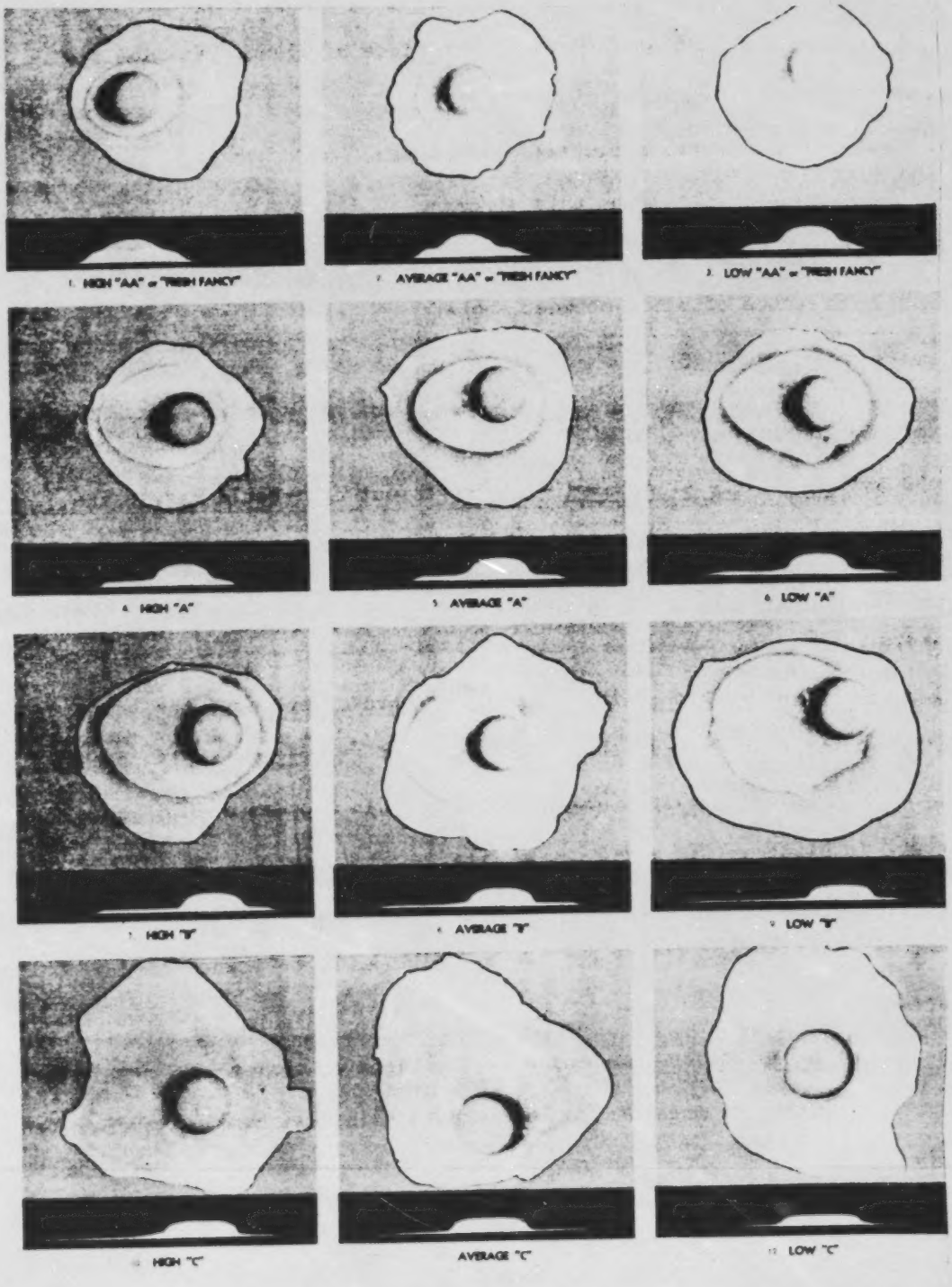
SHELL
- cuticle
- spongy (calcareous) layer
- mammillary layer

MEMBRANE
- air cell
- outer shell membrane
- inner shell membrane

MEASURING AIR CELL DEPTH



EGG BREAK-OUT QUALITIES



Glossary of Terms

1. Belling - The practice of tapping two eggs together gently to determine if one or both of the eggs have a blind check.
2. Class - The different kinds of poultry have distinctive characteristics which enable a grader to classify them. Some of the classes of chickens are broiler-fryer, roaster, capon, and stag.
3. Mediterranean Class - Refers to the area where the breed or variety of chicken was developed. Some other classes are American, English, and Hamburgs.
4. Condition - This refers to evidences of disease or other factors which may render the carcasses unfit for human food.
5. Checked or cracked - An egg that has a broken shell or crack in the shell. Its shell membrane is in tact and the contents are not leaking.
6. Haugh Unit - A unit of measurement used to express the height of the thick white (albumen) of broken-out eggs.
7. Kind - Refers to the different species of poultry, such as chickens, turkeys, and ducks.
8. Leaking or leaker - An egg that has a crack or break in the shell and shell membranes and the contents are exuding or free to exude through the shell.
9. Molting or molt - The shedding of feathers by laying hens.
10. Smashed - An egg with a shell that is crushed or shattered.
11. Sound - An egg with an unbroken egg.
12. Chicken varieties - Subdivisions of the breeds of chickens. These are determined by plumage color and the comb.

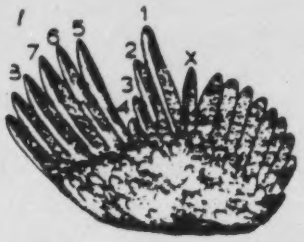
Student Activities

Complete the following sentences, or provide the information requested.

1. The emphasis is placed on the _____ _____ _____ the birds have laid when judging production classes.
2. The number of decisions may be reduced by _____ the birds when judging production classes.
3. The single most important factor in placing production hens is _____.
4. If a class cannot be placed on pigmentation, the next factor to consider is _____ _____.
5. List the average number of eggs usually required to fade the pigment in the body parts of laying hens listed below.

   a. One-third of beak _____
   b. Two-thirds of beak _____
   c. Front of shanks _____
   d. All of shanks _____
   e. Bottom of feet _____
   f. Front of shanks _____

6. Factors that affect the rate of pigment fades are (1) _____, (2) _____, (3) _____, and (4) _____.
7. Factors that affect the speed pigment returns to the body parts when hens cease laying are (1) _____, (2) _____, (3) _____, and (4) _____.
8. a. The abdominal capacity is usually measured and expressed by _____ width.
   b. A measurement of 3 by 5 means that there are _____ _____ width between the _____ bones and _____ _____ width between the _____ bones and the _____ bone.
9. The order feathers are dropped when hens molt is _____, _____, _____, _____, _____, and _____.
10. With primary and secondary feathers similar to the illustration below, how long would a hen have been in a molt?



Answer in weeks: _____

11. The most important consideration in judging production pullets is _____ _____.
12. Good indicators of the sexual maturity of production pullets are the _____ and _____.
13. The head on production pullets is a good indicator of _____-_____.
14. Fat accumulation on ready-to-cook poultry can best be evaluated in the _____ _____ _____.
15. Fleshing of ready-to-cook poultry refers to the _____ _____ _____.
16. The _____, _____, and _____ contain most of the fleshing on ready-to-cook broiler-fryers.
17. The two types of pinfeathers are _____ and _____.
18. Grade the birds in the following illustrations on conformation.

Quality _____

Quality _____

19. Indicate the grade of the turkey carcasses to the left of the statement.

_____ a. A 14-lb. hen with a two-inch tear on its breast.
_____ b. A 12-lb. hen with a protruding broken bone in the left wing.
_____ c. A 10-lb. hen with one disjointed and one broken bone.
_____ d. A slight curve in the breast bone of a 10-lb. hen.
_____ e. A three-inch tear on the back of a 10-lb. hen.

20. Indicate the grade of each of the ready-to-cook broiler-fryer carcasses to the left of the statement.

_____ a. Tailhead missing.
_____ b. Broken drumstick.
_____ c. A two-inch tear on back.
_____ d. Left wing missing at second joint.
_____ e. An 1 1/4 inch skin tear on thigh.

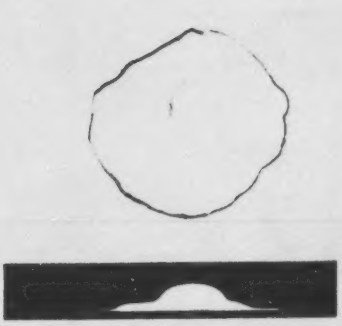
21. Indicate the U.S. grade of the exterior quality of the egg to the left of each statement.

_____ a. A practically normal shell.
_____ b. A slightly abnormal shell.
_____ c. An egg with 1/32 of the shell surface having localized stain.
_____ d. Scattered stain covering 1/16 of the egg surface.
_____ e. A shell with adhering dirt.

22. Indicate the grade of the interior quality of the egg to the left of the statement.

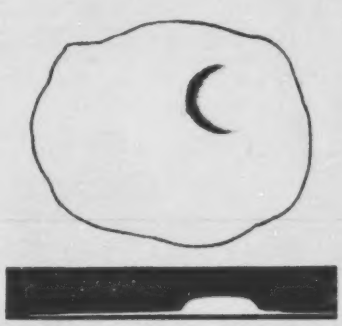
_____ a. Air cell is tremulous and 1/8 inch in depth.
_____ b. Air cell has 1/4 inch movement from normal position.
_____ c. A 1/4 inch diameter meat spot.
_____ d. An egg with a slightly enlarged and slightly flattened yolk.
_____ e. An egg with a slightly weak albumen and definite germ development.

23. Designate the U.S. grade of the broken-out eggs shown in the illustrations.



Quality _____

Quality _____



Quality _____

HORSES AND HORSEMANSHIP

Instructor's Guide

1. This is an option unit to the Ag II Guide. If horse production is economically feasible in your area a unit on Horses and Horsemanship may be appropriate.
2. This unit is very basic, if more advanced materials are required you should consult with local horse producers.
3. The materials presented here were selected from a University of Illinois publication No. VAS 1047.
4. It is recommended that the justification for a horse production unit not be because they are a popular play thing.

Objectives

Upon completion of this unit, the student will be able to:

1. Identify breeds of light horses.
2. Select a horse.
3. Determine the horses age.
4. Develop feed rations for horses.
5. Care for a horses health.
6. Care for the shelter needs of a horse.
7. Groom a horse.
8. Train a horse.
9. Purchase equipment for horse care and training.
10. Bridle and saddle a horse.
11. Know basic horsemanship.
12. Fit a horse for show.
13. Show a horse at the halter.
14. Appreciate safety considerations while near horses.

Student Activities

1. Read objectives.
2. Read information sheets.
3. Judge horses.
4. Bridle and saddle horses.
5. Fit a horse for show.
6. Calculate feed rations.
7. Groom a horse.
8. Ride a horse.

Teaching Aids

1. Read objectives.
2. Information sheets.
3. Community contacts that will allow students to handle, groom, and ride their horses.

References

1. VAS 1047, Horses and Horsemanship, University of Illinois, Urbana, Illinois.
2. The Stockman's Handbook, Ensminger, The Interstate Printers & Pub., 1978.
3. Horses and Horsemanship, Ensminger, The Interstate Printers & Pub., 1977.
4. The Horse Handbook, Vocational Education Productions, Cal Poly & State University, San Luis Obispo, California.
5. The Beginners Guide to Buying a Horse, Vocational Education Productions, Cal Poly & State University, San Luis Obispo, California.

HORSES AND HORSEMANSHIP

1. What Are the Breeds of Light Horses?
2. What Should I Look for When Judging Horses?
3. How Can I Tell a Horse's Age?
4. How Should I Feed My Horse?
5. How Should I Care for My Horse's Health?
6. What Shelter Should Be Provided for Horses?
7. How Should I Groom and Care For My Horse?
8. What Is the Best Method of Training a Young Horse?
9. What Equipment Do I Need?
10. How Should I Bridle and Saddle My Horse?
11. Some Basic Horsemanship.
12. How Should I Fit My Horse for the Show?
13. Showing at the Halter.
14. Safety Precautions

This publication was prepared to help you care for and use your horse properly, and to have fun while learning. Not all cowboys/cowgirls are good horsemen/horsewomen and many top horsemen/horsewomen have never been cowboys/cowgirls. Both, however, do follow certain basic principles in handling horses.

In becoming a good horseman or horsewoman you will need to train yourself in addition to training your horse. You need to earn respect for your horse, responsibility in caring for your horse, discipline in the way you handle yourself around horses, patience in training, neatness in your own and your horse's appearance, and pride in yourself when you know that what you have done is admired and respected by friends and others who see you with your horse.

There are no shortcuts or half-measures. To learn to be a good horseman/horsewoman requires knowing all you can learn about horses and, then, using that knowledge every time you ride. You will be repaid by a well trained horse, responsive to your wishes and willing to give you its best if not abused. The experience of riding a top horse is one you will never forget once you have had the chance.

This subject matter unit covers breeds of horses, judging, feed and care, equipment, showing, and basic horsemanship. Good horsemen/horsewomen know and use this type of material everytime they ride. The more you learn from this basic material, the more you will find new ideas and methods coming to your attention. Keep an alert, open mind and use all the ideas you can.

1. WHAT ARE THE BREEDS OF LIGHT HORSES?

What is a breed? The names Arabian, Quarter Horse, Thoroughbred, etc., are heard frequently when talking about horses. These are the names given to some of the breeds of horses.

A breed is a group of animals which was started from a common origin. Each group, or breed, has definite breed characteristics not commonly seen in the other breeds. These characteristics are fixed in the genetic makeup of the breed and will be passed on from the parents to their offspring. Most people can tell a Chevrolet from a Ford by the body styles. Learn to know horse breeds the same way.

The most popular saddle breeds include the Quarter Horse, Arabian, Appaloosa, Morgan, Thoroughbred, American Saddle Horse, and Tennessee Walking Horse. Popular pony breeds for the smaller riders are the Shetland, Welsh, and Pony of the Americas. Excellent riding horses are produced by crossing these breeds. Your library should include a book telling the history and descriptions of the breeds of horses.

When selecting your horse, select a healthy, sound, well-mannered, saddle-type horse that is strong in one of the lines of breeding mentioned before. As you learn more about horses, you will find yourself liking one breed better than you do others. This is the time to get a good purebred of that breed. Remember, that every breed has good points, but no matter what its breeding, your horse can only be as good as your ability to handle it.

Horses are classified, regardless of breeding, to the purpose for which they are best suited. The following classification is a practical guide for use in selecting an animal. You will find the stock horse used most frequently on stock farms and for western pleasure riding. Three-gaited horses, hunters, and jumpers are popular in a few local areas.

1. Stock horse. A short coupled, deep bodied, and well-muscled horse developed for work under the saddle on cattle farms and western ranches.

2. Three-gaited pleasure horse. Horses of this type are found in all of the light breeds. They are popular for pleasure riding at the walk, trot, and canter. Three-gaited pleasure horses usually are longer coupled than the stock horse and lack the extreme style and action of the park hack.

3. Walking horse. These horses were originally developed for plantation riding. They are characterized by an easy running walk. Tennessee Walking Horse breeding usually predominates, although some walking horses carry considerable blood of some of the other breeds.

4. Hunter. A Hunter is a large, clean-cut horse bred for cross-country riding and jumping. They are usually purebred or grade Thoroughbreds, selected for stamina, speed, and surefootedness.

5. Ponies. Ponies are small horses, under 14.2 hands in height at maturity. Most common are the minature Shetland and the medium-size Welsh pony. These two breeds are often crossed with Arabs, Morgans, and other breeds of light horses to produce larger, more spirited ponies for experienced teenagers. Hackney ponies are noted for their high trotting action for light carriage use.

2. WHAT SHOULD I LOOK FOR WHEN JUDGING HORSES?

Horse judging is more than just a contest or game. You judge a horse on its conformation and body structure in relation to the work it will be required to do.

All horses, regardless of the breed, must have certain body characteristics to make them suitable for riding. Good feet and legs, sloping shoulders, bright clear eyes, and strong short-coupled backs are a few examples. As you consider different breeds, you will find characteristics that are important in relation to the purposes for which the breed was first formed. Here we have the size and ranginess of the Thoroughbred for racing long distances; the stock horse type of the well-muscled Quarter Horse for short bursts of speed, fast turns, quick get-away, and weight for handling cattle; and the shorter coupling and docility of the Arabian matched with style and grace for endurance and beauty.

The scorecard lists the major points to consider when you are judging a saddle horse. The pictures and drawings show the parts of a horse and how these parts should appear on an ideal horse. Learn to know these parts by name. Know the terms used to describe horses, the correct way the parts should appear, and how they look when they are faulty. Study the scorecard descriptions closely and get an idea of the relative value of each of the divisions.

You will not find a perfect horse. Each has its faults and good points. You will need experience to learn how to balance these points.

Judging Procedure

The class is ready to be judged. You are expected to place the horses in order and also remember the good points and bad points of each horse so you can give reasons for the way you placed each one.

Stay back -- get a long range view of each horse. This gives you an idea of the general appearance. General appearance is the first division on the scorecard. Look for the points mentioned under that division.

After you have studied the general appearance, it is time to move closer. Learn to follow a definite method every time. The best

way is to follow the order given on the scorecard. Move quietly and steadily around the horse. Go first to the head and examine the forehand, body and the side view of the hindquarters. Continue on to a position in back of the horse for a look at the hindquarters and legs from the rear. Stay back so you won't get kicked. You cannot get a good look too close anyway. Continue on around the off side of the horse. Compare the body and forehand from this side and end up at the head. Even though the exhibitor is handling the horse, you should speak to it any time you move in close, so the horse will know where you are

By learning to follow this definite method, you will find the points of the scorecard easier to remember since you relate them to each horse in a definite order.

Learn to picture each horse in your mind by some identifying feature of the horse. Was it the darkest horse in the class? the smallest? did it have a blaze or stripe? By doing this, and concentrating, you can see each horse in your mind as you give reasons. If you learn to do this, it is almost as good as having the horses in front of you as you talk. This is how a horseman/horsewoman remembers the horses they have seen and can tell you about them long afterward.

Make a practice of mentally judging every horse you see. Study your own horse and soon you will find judging will become a habit.

SCORE CARD FOR THE SADDLE HORSE

Scale of Points	Standard or Perfect Score
General Appearance - 12 percent	
1. Height	
2. Weight	
3. Form (Close but not full made, deep but not broad, symmetrical)	4
4. Quality (Bone clean, dense, fine, yet indicating substance. Tendons and joints sharply defined, hide and hair fine; general refinement, finish)	4
5. Temperament (Active, disposition good, intelligent)	4
Head and Neck - 8 percent	
6. Head (Size and dimensions in proportion, clear-cut features, straight face line, wide angle in lower jaw)	1
7. Muzzle (Fine, nostrils large, lips thin, trim, even)	1
8. Eyes (Prominent orbit; large, full, bright, clear; lid thin, even curvature)	1
9. Forehead (Broad, full)	1
10. Ears (Medium-size, pointed, set close, carried alert)	1
11. Neck (Long, supple, well crested, not carried too high, throttle well cut out, head set on well)	3
Forehand - 22 percent	
12. Shoulders (Very long, sloping, yet muscular)	3
13. Arms (Short, muscular, carried well forward)	1
14. Forearm (Long, broad, muscular)	1
15. Knees (Straight, wide, deep, strongly supported)	2
16. Cannons (Short, broad, flat, tendons sharply defined, set well back)	2
17. Fetlocks (Wide, tendons well back, straight, well supported)	2
18. Pasterns (Long, oblique - 45 degrees - smooth, strong)	2
19. Feet (Large, round, uniform, straight, slope of wall parallel to slope of pastern, sole concave, bars strong, frog large, elastic, heels wide, one-third height of toe, horn dense, smooth, dark color)	5
20. Legs (Direction viewed from in front, a perpendicular line dropped from the point of the shoulder should divide the leg and foot into two lateral halves; viewed from the side, a perpendicular line dropped from the tuberosity of the scapula should pass through the center of the elbow-joint and meet the ground at the center of the foot)	4
Body - 12 percent	
21. Withers (High, muscular, well finished at top, extending well into back)	3
22. Chest (Medium-wide, deep)	2
23. Ribs (Well sprung, long, close)	2
24. Back (Short, straight, strong, broad)	2
25. Loin (Short, broad, muscular, strongly coupled)	2
26. Flank (Deep, full, long, low underline)	1
Hindquarters - 31 percent	
27. Hips (Broad, round, smooth)	2
28. Croup (Long, level, round, smooth)	2
29. Tail (Set high, well carried)	2
30. Thighs (Full, muscular)	2
31. Stifles (Broad, full, muscular)	2
32. Gaskins (Broad, muscular)	2
33. Hocks (Straight, wide, point prominent, deep, clean cut, smooth, well supported)	5
34. Cannons (Short, broad, flat, tendons sharply defined, set well back)	2
35. Fetlocks (Wide, tendons well back, straight, well supported)	2
36. Pasterns (Long, oblique - 50 degrees - smooth, strong)	2
37. Feet (Large, round - slightly less than in front - uniform, straight, slope of wall parallel to slope of pattern, sole concave, bars strong, frog large and elastic, heels wide, full, one-third height of toe, horn dense, smooth dark color)	4
38. Legs (Direction viewed from the rear, a perpendicular line dropped from the point of the buttock should divide the leg and foot into lateral halves; viewed from the side, this same line should touch the point of the hock and meet the ground some little distance back of the heel; a perpendicular line dropped from the hipjoint should meet the ground near the center of the foot)	4
Way of Going - 15 percent	
39. Walk (Rapid, flat footed, in line)	5
40. Trot (Free, straight, smooth, springy, going well off hocks, not extreme knee fold)	5
41. Canter (Slow, collected, either lead, no cross canter)	5
Total	100

Terms Relating to Horses

Definitions

1. Foal. A young horse of either sex up to yearling.
2. Filly. A young female under 5 years.
3. Colt. A young male horse up to 5 years. (Also commonly used in a broad sense as any member of the horse family (Equidae), which includes the asses, zebra, etc.)
4. Mare. A mature female 5 years old.
5. Horse or Stallion. A mature male.
6. Gelding. An unsexed male.

Meanings of terms often used to describe animals.

1. Balance. Depth and width from front to rear with all parts blending smoothly, giving a pleasing appearance to the eye.
2. Bloom. Usually refers to hair that is clean, fluffy, and of a healthy, fine texture.
3. Characteristics. Identifying or distinguishing points or parts.
4. Coarse. Rough, harsh appearance; lacking refinement.
5. Conformation. Body shape or form.
6. Mellow hide. Soft, pliable, and easy to handle.
7. Paunchy. Applied to an animal which carries too much belly.
8. Quality. Fineness of texture; freedom from coarseness.
9. Soundness. Freedom from any abnormal deviation in structure or function which interferes with the usefulness of the individual.
10. Stylish. Having a pleasing, graceful, alert, general appearance.
11. Symmetrical. Proper balance or relationship of all parts.
12. Action. Straight and true, clean cut, free, and bold.
13. Thrifty condition. Healthy, active, and vigorous.

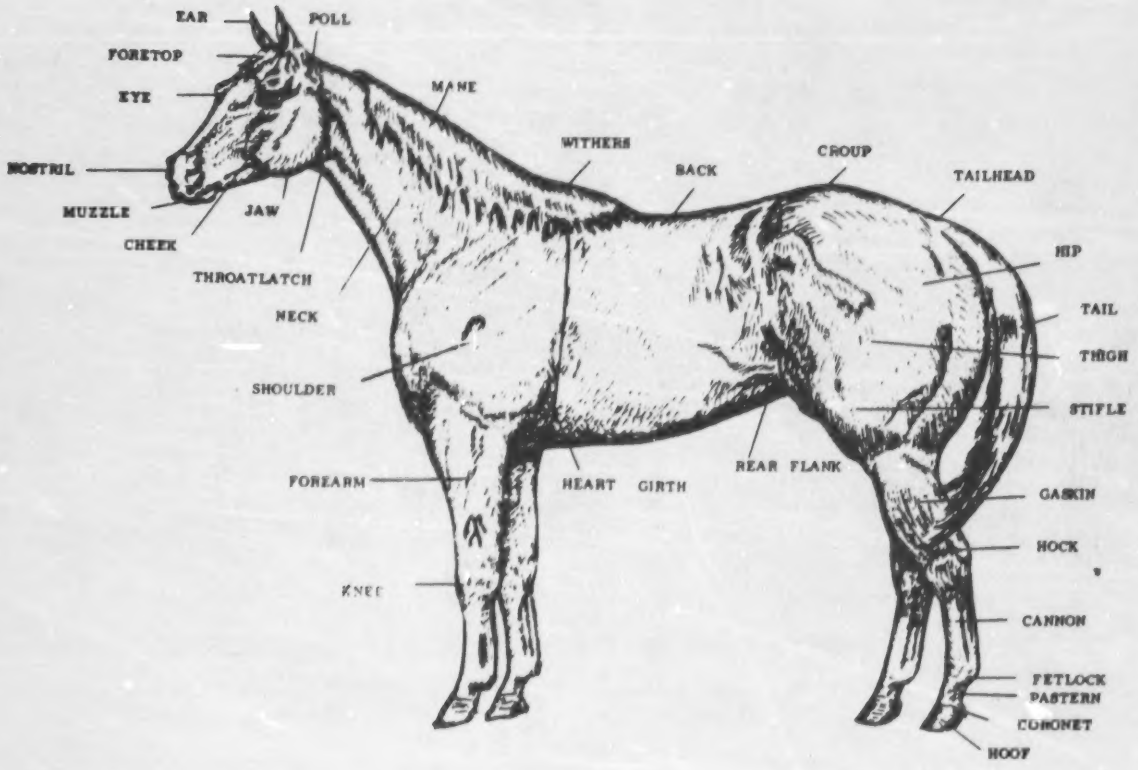


Fig. 1. You need to know the parts of a horse before you can fully understand the scorecard.

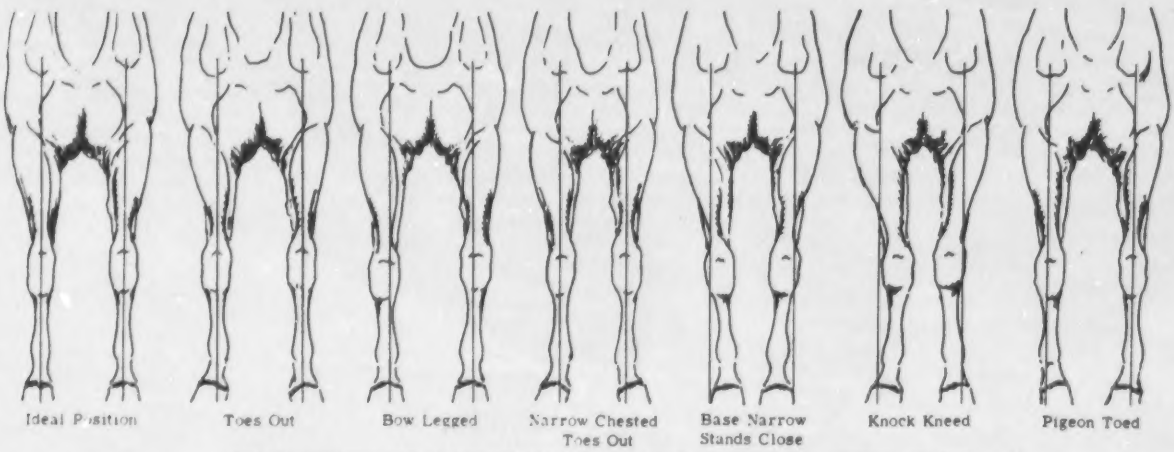
PARTS OF A HORSE

The parts of a horse are shown in Fig. 1. As you learn the location of each of the parts, take time to learn the description of the part given in the scorecard. If you do this, you will find the description will automatically be remembered when you name the part. As an example -- when you name the eye, you will immediately think of a bright, full eye showing alertness and intelligence, in contrast to a narrow, dull eye that is small and not watching every move you make.

Feet and legs

The feet and legs of a horse are important. The old saying, "no feet - no horse", still applies. The importance of the meaning of this saying can be best explained by modernizing the wording to, "no wheels - no car", and everyone knows how far a car can move with no wheels. The scorecard description of the feet and legs uses perpendicular lines to serve as guides in determining the correct

positions of these parts. Figs. 2, 3, 4, and 5 illustrate the correct postions of the legs and some incorrect positions commonly seen in horses. The influence of each of the positions on the horse's movements (way of going) is also shown. These leg positions are important because of their relation to the soundness of body structure of the horse. The effect of these positions on the way the horse moves has been shown. In the section on soundness you will learn how the poor leg positions cause reactions in the body of the horse resulting in bone and muscle changes which make a horse unsound.


Ideal Position
Toes Out
Bow Legged
Narrow Chested Toes Out
Base Narrow Stands Close
Knock Kneed
Pigeon Toed
Vertical line from point of shoulder should fall in center of knee, cannon, pastern, and foot

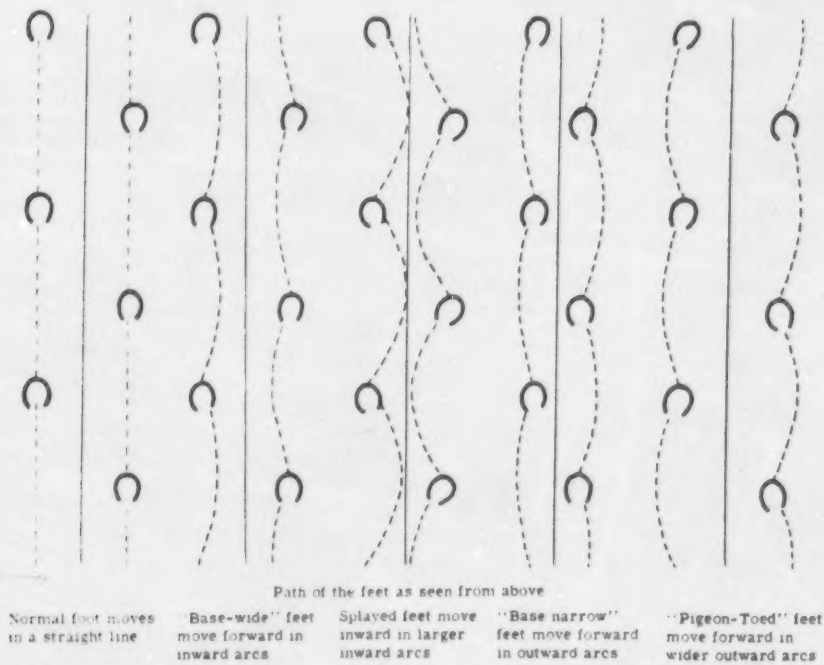

Path of the feet as seen from above
Normal foot moves in a straight line
"Base-wide" feet move forward in inward arcs
Splayed feet move inward in larger inward arcs
"Base narrow" feet move forward in outward arcs
"Pigeon-Toed" feet move forward in wider outward arcs

Fig. 2. Correct and incorrect positions of front legs, as shown from the front, and the influence of each on the movement of the horse.

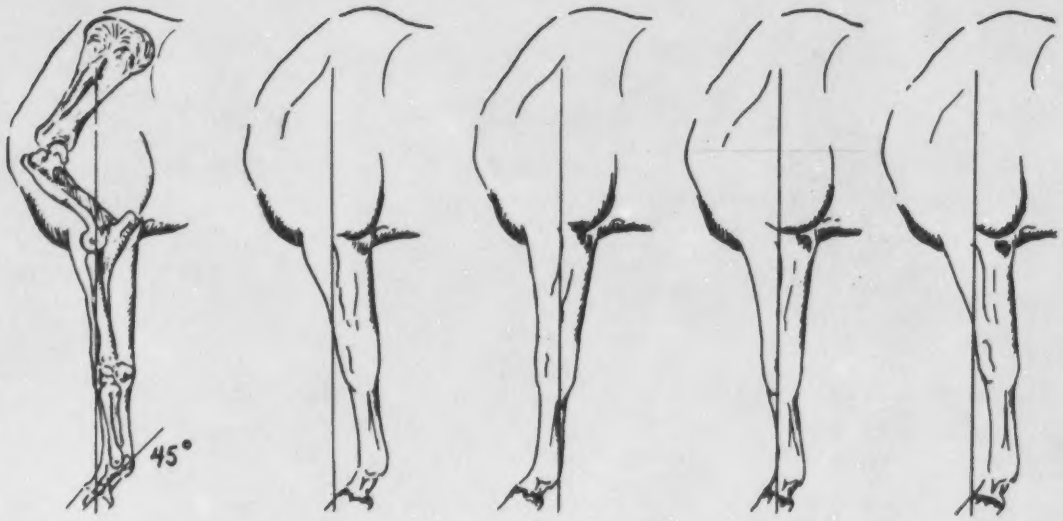


Fig. 3. Correct and incorrect positions of front legs, as shown from the side.

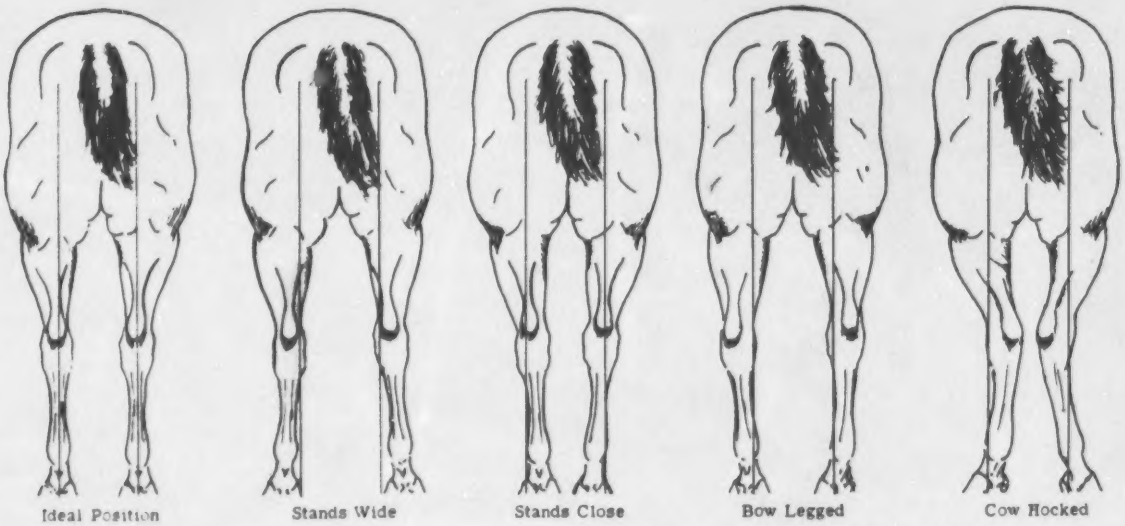
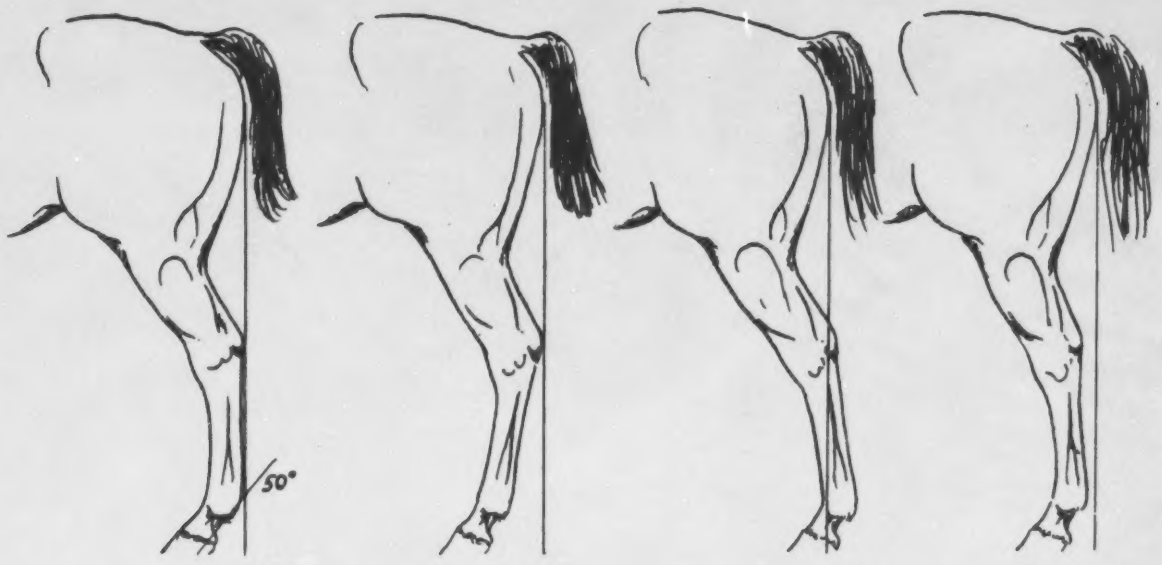

Ideal Position
Stands Wide
Stands Close
Bow Legged
Cow Hocked
Vertical line from point of buttock should fall in center of hock, cannon, pastern and foot.

Fig. 4. Correct and incorrect positions of rear legs, as shown from the rear.



Ideal Position | Stands Under | Camped Out | Leg Too Straight

Vertical line from point of buttock should touch the rear edge of cannon from hock to fetlock and meet the ground behind the heel.

Fig. 5. Correct and incorrect positions of rear legs, as shown from the side.

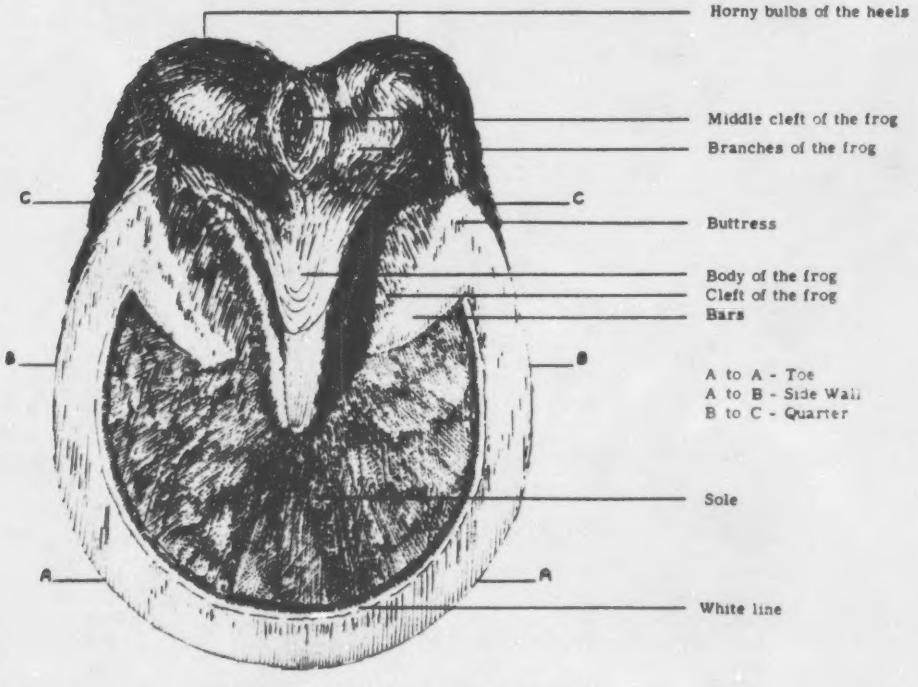


Fig. 6. The hoof of a horse is more complicated than most people realize. To understand it you need to know the parts and their functions.

The structure of the foot is equally as important as the legs. Make it a habit to give regular care to the feet. This care should be followed just as faithfully as the steps you take when brushing and saddling your horse before riding. The structure of the foot is shown in Fig. 6. Understand the different parts of the hoof.

Fig. 7 shows the proper angle desired in the pastern and hoof as seen from the side. The dotted line shows the ideal arc the foot will follow as the horse moves. The effect the improper angles have on the action of the foot are shown also.

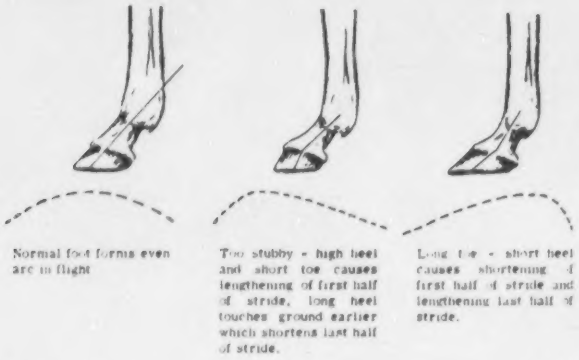

Normal foot forms even arc in flight
Too stubby - high heel and short toe causes lengthening of first half of stride, long heel touches ground earlier which shortens last half of stride.
Long toe - short heel causes shortening of first half of stride and lengthening last half of stride.

Fig. 7. Correct and incorrect angle of the pastern and hoof and the arc of the hoof at each of the angles.

The angles of the front pasterns are related to the slope of the shoulder. The angle of the foot and slope of the shoulder are important factors influencing how smoothly and easily your horse moves. This in turn determines how smooth and easy will be the riding motion you feel when in the saddle. The angle determines how the foot and pastern absorb the terrific shock that takes place when the foot hits the ground.

Proper trimming of the hoof is very important in keeping your horse standing squarely and moving straight. Young horses should be watched closely as they grow. Keep the feet trimmed regularly so the muscles and bones of the feet and legs will develop correctly. A healthy hoof grows about 3/8 to 1/2 inch a month. The fastest growth is at the toe of the hoof. Trimming should be done every month or six weeks depending on the rate of growth. Do not let hoofs grow long during winter months, or when you are not using your horse, and then expect the horse shoer to correct the feet at the first shoeing. Keep the hoofs trimmed.

Corrective trimming and shoeing is necessary on some horse to improve or correct defects resulting from inherited faults in conformation. The work should be done only by a person fully experienced in the structure of the foot and leg and the knowledge of corrective measures. Learn the basic points of proper shoeing so you will know when your horse is being shod correctly. A poor job of shoeing can cripple

your horse for long periods. Know what is correct and insist that the job be done right.

The hoofs of a horse will dry out rapidly in dry weather. A dry hoof will become brittle and crack, and the frog will lose its elasticity. Keep your horse's hoofs moist. A hoof that is left dry too long will cause the frog to shrink and the heel to contract. Hoof dressing may be applied. One of the best preventions is to have some moist ground, possibly around the watering facilities, where the horse will stand long enough for moisture to go into the hoofs.

Unsoundness and blemishes

Blemishes are imperfections found on a horse that do not affect its serviceability. Wire cuts, rope burns, and saddle marks are examples.

Unsoundness are the imperfections that affect the serviceability of a horse. Many unsoundnesses are the result of weaknesses in the structure of the horse's body. These weaknesses appear when the horse places too much strain on some of its weak parts.

No horse is perfect. It is to your advantage to know the common unsoundnesses and blemishes and then judge their importance in relation to the use you plan for your horse.

Fig. 8 shows the location of some common unsoundnesses. Many good books on horses give a more detailed description of each of the unsoundnesses shown if you are interested in reading further on any of them.

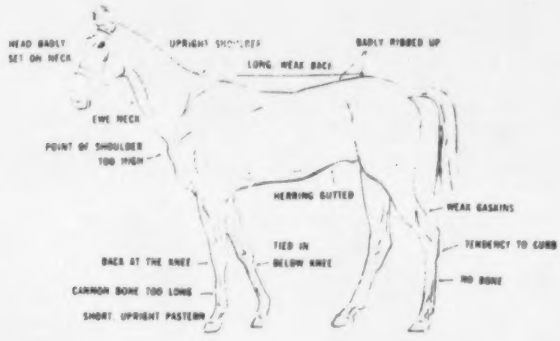


Fig. 8. Some unsoundnesses of a horse.

Body color and markings

The terms describing body colors and markings are used frequently by horsemen/horsewomen. They are used to identify a horse for registration or when just talking about horses.

The color guide and markings illustrated are based upon the official rules of the Jockey Club for registering purebreds (Figs. 9 & 10). Use them to help you remember a horse when you are judging.

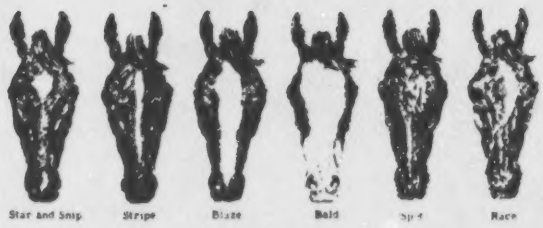


Fig. 9. These are the most common face markings found on horses.

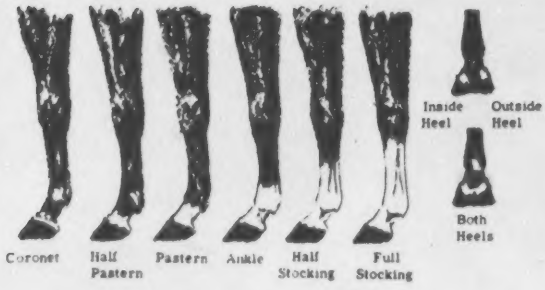


Fig. 10. Leg markings differ by the amount of white on the legs.

Bay. Light bay (yellowish tan). Blood bay (bright mahogany). Dark Bay (dark rich shade, almost brown).

Brown. Very dark, almost black, with tan or brown hairs on the muzzle or flanks.

Black. Black color with fine black hair on muzzle. If question of dark brown or black, the color of the muzzle hairs will help decide.

Chestnut. Ranges from light washy yellow to a dark liver color. Red, gold, and copper shades are between the two extremes. A horse of this color class never has black mane, tail, or points.

Dun. Mouse colors to golden dun. Has black points, mane and tail.

Gray. Mixture of white and black hairs. May appear as black at birth but coat changes to appear light with age.

Roans. Red or strawberry roan -- has hairs of red, white, and yellow intermingled.

Blue roan -- black, white and yellow hairs intermingled.

The breed associations have slightly different descriptions for their colors. Learn those for your favorite breed. Other color patterns

are also used in descriptions. They include the following:

Buckskin. Form of dun -- yellowish or gold body color -- black mane and tail, usually black on lower legs.

Appaloosa. Solid color or mottled roan foreparts with lighter color over loins and hips, containing dark round or egg shaped spots. Some white with spots over entire body. Mares often less colorfully marked, being a mottled roan over the entire body.

Dapple. Light or dark spots appearing over the basic body color.

Palomino. A golden body color, varying from light yellow to a bright copper color, with white mane and tail.

Pinto, Paint, Pied. Piebald -- white and black combination.

Skewbald. White and any other color but black.

Following are descriptions of several of the color terms used above:

Black points. Horse has a black mane, tail, feet and legs.

Ray or dorsal stripe. Dark line found down the back bone of some horses.

Zebra marks. Dark stripes running horizontally on the forearm, knees, and cannon region.

3. HOW CAN I TELL A HORSE'S AGE?

Horsemen/horsewomen use the front teeth of a horse to judge the age of the animal. The material presented here is designed to give you simple clues to follow in determining the age of a horse. Determining the age of a horse by its teeth takes much practice. Do it with the help of an experienced person.

A mature male horse has 40 teeth. There are 12 front teeth, called incisors; 4 tushes, or bridle teeth; and 24 molars, or grinders. A mature mare has only 36 teeth. The 4 tushes are seldom present. The young horse, either male or female, has 24 temporary, or "milk teeth". There are 12 incisors and 12 molars. These milk teeth are smaller and whiter than the permanent teeth.

First, learn the names of the incisors, as shown in Fig. 11.

From birth to five years of age, the eruption of the incisors is used to judge the age. At five years the permanent incisors are all in place. After five years the age is determined by the wear of the incisors, the shape of the biting surface, and the angle at which the incisors meet. For general purposes you should learn to judge the approximate age range by holding the lower lip down for a quick glance to see the shape of the teeth, the angle at which the upper and lower incisors meet, and the degree of wear shown by the length of the teeth. You can then consider the age as being in the foal period, the full-month period (5 years), the smooth-mouth period (11 years, approximately), and the old mouth. Remember that most horses are beginning to serve their best at 8 years and many are still going strong up to 15 years or more.

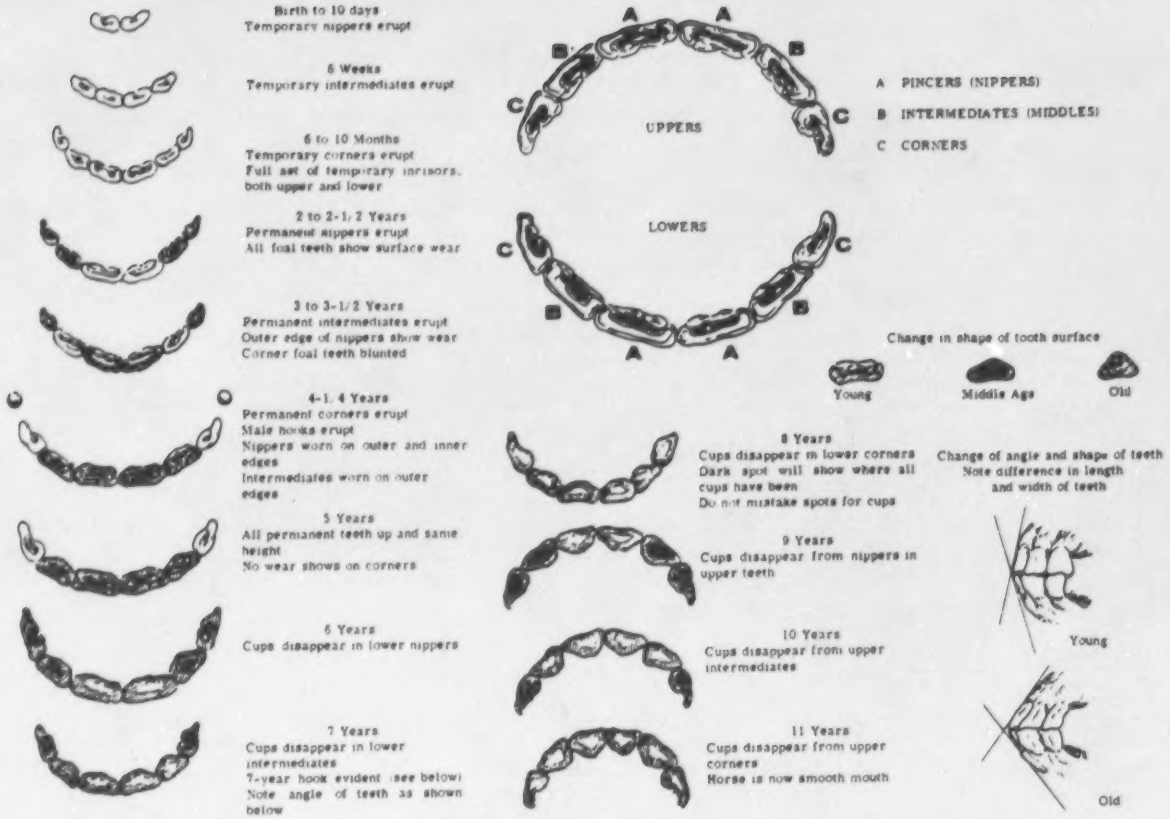


Fig. 11. The number of permanent incisors may be used to determine age to 5 years. After that, use the shape of the biting surface and the angle of the incisors.

Study the illustration for the points given to look for at each year of age. Practice looking at teeth every opportunity you have.

4. HOW SHOULD I FEED MY HORSE?

Proper feeding of horses is based upon principles that are easy to understand if you learn the terms used when talking about nutrition. You already think of your feeds as hays, grains, pastures, vitamins, minerals, salt, and water.

All of these feeds supply certain nutrients needed by your horse. Definite amounts are needed just to maintain the body. Larger amounts are needed for the work the body must do. When you feed properly, you are supplying the body with the energy, proteins, and minerals it uses up as it works. The harder the work the more it uses, and the more you must supply in the feed. These nutrients needed by the body must be digestible (capable of being broken down and used by the body) or they pass right on through.

Think of these nutrients as building blocks. Several different kinds are needed. First are the total digestible nutrients (commonly referred to as TDN). These include all the heat or energy valves of the feeds -- the fuel to maintain the body. Second, are the proteins, commonly referred to as digestible proteins (DP). The proteins are essential to all life. They form the greater part of the muscles, the internal organs, the cartilages and connective tissues, the outer tissues (skin, hair, hoofs, etc.), and the nervous system. Third, we have the minerals. These are present in very small growth and the functions of the blood and the vitamins. These are very necessary to the body for growth, reproduction, lactation, and general health. Different vitamins are needed for separate functions.

The TDN, DP, minerals, and vitamins are the building blocks. Feeds are classified into groups based upon the amounts of these nutrients they contain.

Concentrates is the name given to the feeds you know as grains and protein-rich supplements. The grains are high in TDN and low in fiber content. They average 75 percent TDN, or to express it in terms of feed, you need four pounds of grain to supply your horse with three pounds of TDN. Since your horse can only eat so much feed at one time, you will find it necessary to feed the higher energy concentrates (grains) to supply the requirements (or body fuel) needed for harder work.

Roughages are feeds high in fiber and low in TDN. These are the hays, silage (pastures are green roughages), and straw. Roughages average about 50 percent TDN. You must feed eight pounds of hay to supply your horse with four pounds of TDN. At hard work a horse cannot eat enough roughage to furnish all the nutritional requirements needed.

Several rules will help you decide what you need to feed. Concentrates (grains) are generally low in protein. Alfalfa hay or other legume hays are generally high in protein. You will need to add a protein supplement if your feed is mostly grain and no legume hay is fed. The grains are low in calcium while the legume hays furnish some calcium. Phosphorus is usually low in all feeds. In deciding what to feed you are attempting to balance your feeds -- you are selecting the "building blocks" you know your horse needs.

The feeds have been scientifically analyzed and tables are available showing how much TDN and DP is available in a pound of each of the feeds.

The requirements of horses have been studied and tables are available showing how much TDN and DP a horse needs based upon the weight of the horse and the work it must do.

To balance a horse ration, add the TDN and DP found in each of the grains and hays you are feeding. This will give you the total amounts your horse is getting. Then, compare these totals needed for a horse that is about the same size and working about the same as your horse.

After you are satisfied that the feeds you are giving your horse contain all the essential nutrients, you should still watch your

horse to see how it holds its condition. Each horse is an individual and will need slight changes in the feed to keep it in condition. Use your eyes to learn how your horse looks when in good health. Study the skin, shine of the hair, brightness of the eyes, body fleshing, the general attitude, and the manure. Get an oldtime horseman/horsewoman to explain what they look for. If you know how these signs appear when your horse is healthy, you will be quick to observe any irregularities that are warnings when your horse is off feed or sick.

The table shows the recommended daily feed allowances for horses for each 100 pounds of body weight. Also listed are sample rations. You will find these are generally balanced and will need to vary only in the total amounts fed. Check the nutritive balace of these rations for your own experience.

The basic facts in proper nutrition have been explained. Following are some bits of general information that will be helpful to you.

Feed only good quality hays and grains that are free from dust and mold. If dusty hay must be fed, sprinkle water on the amount being fed at each feeding. Breathing the dust is what harms your horse, not eating it, and dampening the hay will keep the dust down.

Calcium and phosphorus are the two minerals most generally lacking. Steamed bone meal, dicalcium phosphate, and monocalcium phosphate are the most commonly used mineral supplements. A general practice is to feed about one ounce per day.

Recommended Daily Feed Allowance for Horses for Each 100 pounds weight *

Kind of Work	Roughage	Grain	TDN**
Idle	1 1/2	None	3/4
Light work	1 1/2	1/3	1
Medium work	1 1/2	2/3	1 1/4
Heavy work	1 1/2	1	1 1/2
Idle mares with nursing foals	1 1/2	1/3	1
Growing colts after weaning	1 1/2	1	1 1/2

*All figures are in pounds
**Total digestible nutrients

I. With alfalfa or clover hay:
   1. Corn..... 3 parts
      Oats..... 1 part
      Bran..... 1 part
   2. Corn..... 2 parts
      Barley..... 2 parts
      Bran..... 1 part
   3. Oats..... 2 parts
      Wheat..... 2 parts
      Barley..... 2 parts
      Bran..... 1 part
   4. Oats..... 5 parts
      Barley..... 4 parts
      Bran..... 1 part

II. With native hay, timothy, etc.

1.	Oats	3 parts
	Corn, wheat, or barley	1 part
	Bran	1 part
2.	Oats	4 parts
	Bran	1 part
3.	Oats	3 parts
	Barley	2 parts
	Bran	1 part
4.	Barley	3 parts
	Linseed oil meal	1 part
	Bran	1 part
5.	Corn	4 parts
	Barley	4 parts
	Bran	1 part
	Linseed oil meal	1 part

Keep a constant supply of salt for your horse to have free choice. A horse requires about 1 1/3 ounces of salt daily.

Keep fresh, clean drinking water on hand at all times. Your horse will drink 10 to 12 gallons per day. More is required in hot weather or at hard work. In the winter your horse may not drink enough, especially if the water is not heated. Add a little salt to the feed to make your horse drink more.

Never let your horse drink more than a moderate amount of water while they are hot.

Add protein supplements to the ration gradually to avoid digestive upset. Usually 1 lb. to 1 1/2 lbs. daily is fed.

Keep your ration simple. A simple ration is cheaper and, if properly balanced, will fill all requirements.

A healthy, well fertilized pasture is one of the cheapest and best ways to feed your horse. The quality of the grass will vary, and if you work your horse hard, some grain will be needed.

Feed only what is needed and feed at regular times each day. Don't overfeed -- it can ruin your horse.

Learn what other horsemen/horsewomen in your area are feeding but know enough about correct feeding to decide if what you learn is good nutrition.

5. HOW SHOULD I CARE FOR MY HORSE'S HEALTH?

You have invested a large amount of money in your horse. At the same time most of you have found your horse to be a friend and companion that money cannot replace. The horse depends upon you for its health and well being, and in turn gives you the enjoyment and companionship you want.

Learn to observe the health of your horse. You can control many factors that affect your horse's health. Among these are: sanitation of the stables and feeding equipment; clean bright feed; exposure to disease as you use your horse; proper fit of riding equipment; hazards around the stables and pasture; constant observation for injuries or signs of disease, and finally, the way you use your horse.

Many of the above factors are discussed here and all of them are just plain good horsemanship. You will learn them as you ride, but the regular use of them is what counts.

Get acquainted with your veterinarian. A vet is the "family doctor" for your horse. Vet's will be very willing to help you plan and carry on a health program that will include worming, disease prevention, breeding records and problems, and general first-aid practices. Proper treatment of diseases, injuries, and parasites depends on two very important factors; correct diagnosis and knowledge of the proper medication. Every veterinarian knows what health and first aid measures can be safely handled by clients and will teach you the proper procedure.

Following are brief descriptions of the more common diseases, parasites, injuries, and general health problems encountered. Study them for information on what you may encounter with your horse and learn from your veterinarian what to do.

General

Cleanliness is very important. The feed boxes should be dry and cleaned often. The bedding should be dry and clean. Manure should be forked out every time you enter the stable. The stable area should be well drained.

If horses are stabled, be certain there is proper ventilation. Fresh air is needed even in the winter but watch out for drafts. More fresh air is needed if the air smells "close" when you enter the stable. Keep the stable temperature and atmosphere as close to that outside as possible so your horse will be more capable of hard and fast work.

Diseases

Influenza is a respiratory disease, much the same as found in humans. Eight different viruses can cause respiratory disease. Your horse can be easily exposed if you participate in many shows where horses are brought in from other areas.

Signs of these diseases are nasal discharge or cough. For full recovery a long rest period is needed even after medication has been stopped. Complete rest (this means to leave the horse in the stall with no excercise) is needed for 30 days after an attack of influenza. The veterinarian should be consulted for treatment. A vaccine is now available against two of these virus diseases.

Sleeping sickness (encephalomyelitis) is caused by a virus. Two types of virus are known: Eastern and Western. The disease may be fatal, or it can leave your horse in a "dummy" state. Biting insects, particularly mosquitoes, transmit this disease and humans are also susceptable. Sleeping sickness can be prevented by an annual vaccination program.

Thrush is a disease caused by lack of sanitation and proper attention to the feet. The frog of the foot degenerates (breaks down) as a result of this disease. A strong offensive odor is usually the first sign. Lameness will result if corrective measures are not taken.

Grease-heel is a mange-like inflammation of the skin of the pastern

and fetlock. Proper treatment and good sanitation must be followed to prevent the development of running sores. This disease seems to be more commonly found on coarse-legged, thick-skinned horses.

Hoof cracks are vertical cracks or splits in the hoof wall from the coronet down. May be called toe crack, quarter crack, or sand crack (of the frog and sole) depending upon location of the hoof. Usually started by faulty conformation, brittle hoofs, or accidental injury. These cracks may become serious if the underlying sensitive hoof areas become involved.

Corns are similar to the corns found in humans. They are caused by bruising of the sensitive sole of the foot, usually between the bar and the wall. Faulty conformation of the foot is the major cause of corns. Corns are not easy to heal satisfactorily; therefore, qualified help should be obtained early.

Parasites

Worms are a serious problem to your horse's health, especially among the young growing horses. Ascarids (large round-worms), stomach worms, and strongyles (bloodworms) are the three most important. Retarded growth, lack of body condition, and digestive troubles are common symptoms of worms in horses. Death may result from heavy infestations.

The treatment varies depending upon the types of worms. While many horsemen/horsewomen are capable of worming their own horses they obtain help in identifying the worms and using the proper medicants. Check with your veterinarian on the worms found in your area and work out a regular worming program.

Horse bots are special parasites which attack horses. The bot fly annoys horses when laying eggs and the larvae irritate the horse while burrowing through the body. The larvae attach themselves to the stomach and intestinal walls where they feed on the blood of the horse.

Eggs are attached by the fly to the hairs of the horse. The location depends upon the type of bot fly. Check the hairs of the fetlocks and inside of the knees for eggs of the common bot fly; the hairs beneath the jaws for eggs of the throat bot fly; the short hairs of the lips for eggs of the nose bot fly.

Some control may be obtained by washing the eggs off the hairs with a sponge and hot water. If eggs are found, then, bots are surely present in the body and a chemical control program should be started. Watch for the small yellow eggs in the hairs especially in the late summer and fall. Internal treatment should begin one month after the first killing frost.

Flies and mosquitoes are irritating and may transmit diseases. Follow a fly control program around the barn or stable. Several insecticides are recommended for spraying your horse. If the spraying scares the animal, you may mix a solution that can be sponged over the body. Applying an insecticide to the body is only short relief since body sweat will remove the protection. Follow all insecticide recommendations and directions carefully.

Injuries

Teeth wear. As the teeth wear down, sharp points may develop that make it painful to eat. This problem is most serious with young horses under six years of age, and with older horses over twelve years of age. Examine the teeth once a year to determine if floating (filing of the sharp points) is necessary.

Wounds

Wire fences (especially barbed wire) cause tremendous numbers of injuries to horses each year. Add to this the scratches and cuts received from loose nails and projecting boards. Minor cuts may not require suturing. If suturing is required, the sooner it is done after injury, the faster and better the wound will heal. Wounds below the hock and the knee are the most difficult to heal. Most horses with wounds require a tetanus shot for safety.

Every stable should have first-aid equipment for general use. Build your first aid supply and learn proper use of the materials. Remember, that in any disease or injury that occurs to your horse, it is solely dependent upon you for help and recovery. Use your common sense and think clearly. If you have any doubt or question in your mind as to what is wrong or what to do, call for qualified help. Don't gamble.

6. WHAT SHELTER SHOULD BE PROVIDED FOR HORSES?

Shelter for most horses need only furnish protection from hot sun, wind, or stormy weather. The type of shelter depends upon the facilities available. This may vary from an open shed in the corner of the pasture to a small complete stable building with a box stall, tack room, and one or two open stalls.

The stable need not be fancy, but should be well constructed for safety and arranged so it can be kept clean. If mares are to be foaled, a box stall will be very handy for caring for the mare. Some standard dimensions are given below for use in figuring space requirements:

Box Stall	10' x 10' to 12' x 12'
Tie Stall	5' wide 12' long including manger
Ceiling Height	8' minimum
Doors	4' wide 8' high
Hay Manger	28" wide, 38" high top edge
Grain Box	24" to 30" long, 8" to 10" deep, 38" to 42" from floor to top edge.

Your stable or shelter may not fit the dimensions exactly. The important point is to be certain there is room and plenty of ventilation, but no drafts. Plans are available for construction of stables.

Arrange the grain box so it can be easily cleaned. The hay manger should be constructed with an open space at the bottom so chaff, dirt, and trash will fall out, or so you can easily clean out the debris at the bottom.

Regardless of where you keep your horse, always be alert for loose boards, nails, and any projections that can cause injuries. Keep all wire and hay bale twine picked up.

The best fences are constructed of poles or boards. Wire fences, especially barbed wire, cause many horse injuries. A smooth top wire, or a board or pole fastened to the top of the fence will help. Check fences regularly and keep them tight and in good repair.

Your facilities reflect your interest in your horse. Keep them neat, clean, and in repair.

7. HOW SHOULD I GROOM AND CARE FOR MY HORSE?

Your horse likes to be thoroughly groomed. If you groom properly and regularly, you will achieve three goals: A clean shiny coat and skin; a stimulation for the muscle tone of the horse; and a gentling of most horses because they like what you are doing. While grooming, you can also watch for cuts, bruises, and the condition of the feet that might be missed otherwise.

The basic grooming tools include a metal or rubber curry comb, a dandy (coarse bristle) brush, a body (fine bristle) brush, a wool polish cloth, a hoof pick, shears, and a coarsetoothed mane and tail comb. A hacksaw blade, bent double with the two ends fastened with tape, is a handy tool to use as a scraper during the spring when the horse is shedding winter hair. A sponge can be used to clean muddy legs and other dirty areas.

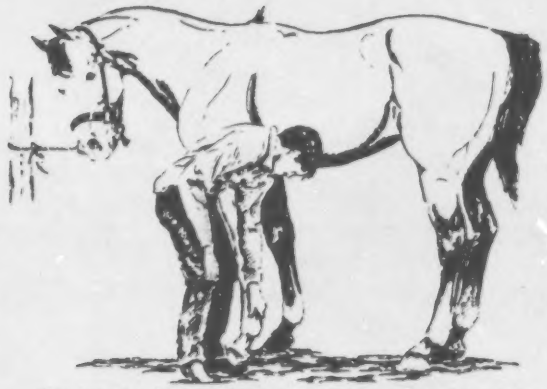
Keep your tools simple. The results are determined by <u>how</u> you use the tools, not by their quality.

Your teacher or neighboring horseman/horsewoman can give you the steps to follow in grooming your horse and tell you how to use the grooming tools properly. A little practice will help you considerably.

Allow some extra time each day to groom your horse before you ride. If you follow a definite system, you can thoroughly clean the horse in a relatively short time. Be thorough. Start at the head and work back on the near side, including the feet and legs. Then, go to the off side and work back. Don't neglect the head (be gentle here) and the area around the tail. Do not use the metal curry comb around the head or below the knees and hocks. There is no fat or muscle in these areas to cushion the hard edges of the curry comb. Use a wet sponge or soft brush to remove dirt from these areas. The newer rubber curry combs may be used carefully to help remove caked dirt.

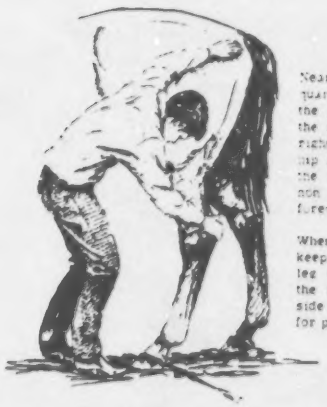
When brushing, use plenty of elbow grease and brush in short brisk strokes. Flick the bristles up at the end stroke so they will throw the dirt out from the hair. Brush with the lay of the hair; this changes direction at different points on the body so look for these changes.

Your hands may be used also. Many oldtime grooms used their hands and fingers to rub and massage the hair muscles. You won't see this being done too often these days because it takes time. Use



Near Forefoot: Slide your left hand down the cannon to the fetlock. Lean against the left shoulder against the horse's shoulder. Reverse for picking up the off forefoot. When the horse shifts weight and relaxes on the foot pick it up.

For a quick cleaning hold the hoof in your free hand. When shoeing or a long cleaning job it will help to place the horse's foreleg between your legs. Hold your knees together to help support the weight of the horse's leg.



Near Hindfoot: Stand forward of the hindquarter and stroke with your right hand from the point of the hip down the hip and leg to the middle of the cannon. As you move the right hand down place the left hand on the hip and press to force the horse's weight to the opposite leg. Grasp the back of the cannon just above the fetlock and lift the foot forward.

When the horse is settled move to the rear, keeping the leg straight and swing your left leg underneath the fetlock to help support the horse's leg. Never pull the foot to the side -- your horse will resist. Reverse sides for picking up the off leg.

Fig 12. This illustration shows how to pick up horses' feet. These are the positions used by veterinarians who handle strange horses constantly.

your hands to rub, scratch, and massage when training a young foal to allow you to handle every part of its body. This is better than "babying" the foal and the foal will like it much more.

Styles today favor the roached mane. The mane is trimmed close to the neck leaving a wisp of hair at the withers and a long foretop. The tail is trimmed to the hocks and thinned enough to keep it neat. Tangles in the mane and tail should be worked out with the fingers and the coarse-toothed comb. Never try to pull them out -- they just become tighter. Watch for burrs and sticks caught in the mane and tail. If you favor the long mane and tail, then, you must expect to keep them combed and hanging neatly.

Proper cleaning of the feet requires that you pick up each foot. Every foal should be taught to allow having its feet picked up and handled. This should be done at the time it is small, when you

are getting it accustomed to the feel of your hands. If you trim the feet as the foal grows, you should have no trouble when it becomes full grown. Fig. 12 shows how to properly pick up a horse's feet.

Always work in order -- near forefoot, near hind, off fore, off hind. This order follows your grooming system. Clean the hoof from heel to toe, paying particular attention to the area around the frog. The cleft and commissures should be cleaned thoroughly to prevent thrush and other foot infections. Watch for rocks, nails, injuries, and loose shoes. Check the growth of the hoof for time to change shoes.

Your pride and interest in your horse are reflected in the way you maintain its appearance. Shortcuts and halfway measures cannot be hidden.

8. WHAT IS THE BEST METHOD OF TRAINING A YOUNG HORSE?

An untrained or improperly trained horse is a nuisance. The cute little tricks a foal learns will soon become bad habits and even dangerous when it grows up.

Don't "baby" your horse, young or old. Be firm about what you want it to do. Use discipline right at the time it is needed but don't be harsh or cruel.

Training methods vary with the trainer and the individual horse. A good trainer knows many methods and, more importantly, when to use the different methods. This takes experience and you never stop learning.

The secret of all training methods is to get the horse to do what you want done without fighting back. The horse learns to do these things by habit. Some learn faster than others, but in either case you, as the trainer, must know what you want and ask for it in exactly the same way each time. Be patient. You will sour a horse by asking too much too soon. Your horse gets too confused.

Training can be separated into that done from the ground (generally for the young horse) and that done from the saddle. The proper method and need for handling the feet has been explained under the section on basic horsemanship. The early training on halter breaking and leading remains to be covered.

Halter break a foal when it is still young. It should learn at this time not to fight the halter and tie-rope. This is important since you will be using lead ropes, tie-ropes, and reins to control your horse all the rest of its life and it must respect the control this equipment gives.

Many horsemen/horsewomen tie the haltered foal near its dam for short periods of time. Others begin halter breaking by leading the foal separately when the dam is being led. Still others will tie foals to a stout fence or pole for several hours at a time and let them learn to respect the halter and rope. A safety measure to prevent injury to the neck muscles consists of a nonslip loop tied around the foal's body immediately behind the withers and elbows with the end running out between the front legs and through the halter ring. This may, then, be

tied to a post, or run around the post and back to the halter ring. When the foal tries to pull back, the pressure of the body loop increases and the foal stops.

This is not cruel as long as you watch to see that the foal does not become entangled and injure itself. A good horseman/horsewoman will keep watch, but leave the foal alone to learn by itself. The foal must learn to respect the rope and halter if you desire control and obedience later on.

The foal should be taught to respond willingly to the lead rope. This is easier if the foal has learned respect for the halter. A good practice at this time is to make a loop with your lariat and drop it over the rump of the foal (Fig. 13).

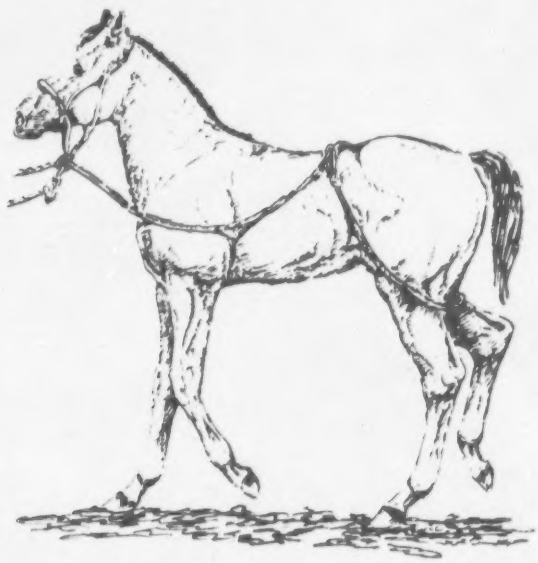


Fig. 13. A rope looped over the rump will prevent much pulling back or resisting the halter rope.

Adjust the loop so that it lies just ahead of the point of the hip and down to the back of the rump under the buttocks. Hold the rest of the lariat so a slight pull will give pressure at the loop if the foal holds back. Never jerk or pull at the head if the foal balks. This will cause the foal to fight back all the harder. Take it easy and pet the foal when it does right. After the foal moves out willingly, you should train it to walk up with its neck even with your shoulder. It should walk freely at the same speed you are moving and increase speed up to the trot when it sees your body moving faster. This is very important training for good halter showing.

The lunge line

Many horsemen/horsewomen use a lariat or light nylon rope not less than 30 feet long. Fasten one end to the halter and hold the

rest of the rope in your hand. Then, stand in a small area and work the horse as it circles around you on the line.

Patience is required to teach a horse that you want it to circle. Up to this time you have trained your horse to walk by your shoulder.

Start by teaching your horse to walk a small circle around you. As the horse learns and responds, increase the size of the circle by increasing the amount of line you let out (Fig. 14).

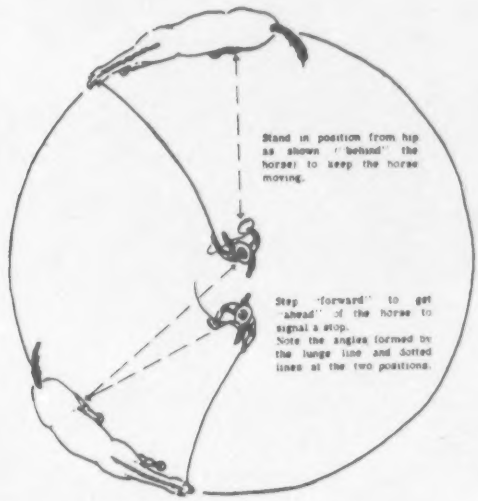

Stand in position from hip as shown "behind" the horse to keep the horse moving.
Step "forward" to get "ahead" of the horse to signal a stop.
Note the angles formed by the lunge line and dotted lines at the two positions.

Fig. 14. Use the lunge line for training and conditioning horses.

Use a light whip to make your horse move out but never strike hard. A touch of the whip or a light flick on the hind quarters will give all the signal needed. Soon you will not need the whip. It is also possible to train your horse to stop when you step forward from this position.

After your horse has learned to circle freely at a walk, and stop when you step forward and say "whoa", begin working it at the trot and slow canter. Always circle both directions equally so your horse will develop muscles and skill both ways of the circle. This is an excellent way for your horse to learn and use the correct leads at the canter and develop its natural balance and grace without the weight of a rider.

Do not work your horse at the faster gaits in a small circle. This will cause the horse to develop a winging action of the feet and legs. Keep your circle large.

Always use the same voice commands and soon your horse will respond to these words.

Use a lunge line for regular excercise and training periods. This is a good way to excercise you horse for a show. Train your young

horses as well as your older horses to respond to the lunge line.

A true horseman/horsewoman does not spend all of the time in the saddle. Learn the fun of training and working your horse from the ground. You will experience a difference in the way your horse responds when you do ride.

Reining

Correct reining is a must in good horsemanship. A well reined horse will turn so easily and quickly on a light neck rein that you will have the feeling the horse is ducking right out from under the saddle. This is true neck reining.

Neck reining is the Western style. Much of the neck reining used today is not true neck reining, but is direct reining in the opposite direction the rider really wants the horse to turn. True neck reining is accomplished by signaling the horse with the weight of the rein against the neck not by the pull of the rein.

Think first of what is happening when you are reining your horse.

Fig. 15. Neck reining is signaling the horse to turn with the weight of the rein against the neck.

Study Fig. 15 and decide which horse is turning more nearly like yours. Note the angle of the head and the rider's hand.

Schooling your horse for better response to your reining signals can be done as you ride. Before you do any schooling, be sure you have your horse settled. If your horse begins to charge when you take up the reins or shift your weight, you cannot school properly. Get control of your horse and ride until it is settled down. School at a walk first. Progress to a slow trot and finally to the slow collected lope, but only after you are getting results. Forget speed.

Most trainers use direct reining (plow reining) when starting young horses. Some use a snaffle bit and long driving lines while others use a bosal. Many use both at different stages. The purpose is to school the horse to "give" its head to the light signal of the reins. You can use these ideas on your horse while schooling. After the horse is going properly, most trainers begin neck reining with direct reining until the horse responds to the neck rein alone. This is the phase of training you can use to school your horse -- light neck rein and some direct rein in combination.

Don't hesitate to use both hands on the reins. You are schooling, not showing. After some practice and response from your horse, you will find you can go back to one hand and signal with your fingers. Some call this "cheating" but in good schooling it is as good horsemanship as shifting weight. It is horsemanship, and the measure of success is how willingly your horse responds after you have schooled it.

Neck rein to turn but do not pull on the neck rein. Just lay the weight of the rein on the neck. With your other hand give a light pull on the inside rein. Pull lightly again, then relax. Continue pulling lightly and relaxing until the horse gives you its head. Don't worry about the full turn yet, you are trying to school your horse into giving its head to the direction of the turn. Work your horse in both directions until it will respond to the w'ght of the neck rein. This is true neck reining.

You will find your style of riding has changed also. You will be lighter in the saddle and more in balance with your horse. You have stopped bracing your body to get force to lift your horse around. You will shift your body to be in balance with your horse which will help the horse turn more smoothly.

Schooling takes time and patience. When schooling your horse, be sure it is calm and under control. Don't try to rush things. If you do, you are right back where you started. This is what you are trying to correct. As you ride around home or over a trail, use the reining discussed here to turn your horse around natural objects in your path. Stay at a walk. This gives your horse a reason for turning and it will naturally learn to follow the shifting of your body when you want to turn at other times.

Some riders use bats and spurs to get response by tapping the neck or spurring the shoulder. Some horses need this but you should know when you can stop using the bat or spur. Don't get the habit of batting or spurring your horse into every turn. Use bats, whips, and spurs as aids to your signals or DON'T USE THEM AT ALL. SCHOOL YOUR HORSE!

More on use of the hands, legs, feet, and body weight as aids in schooling your horse are discussed in the section on horsemanship. Learn these points and use them. You will be surprised at the way 1200 pounds of horse will respond to your slightest signals.

9. WHAT EQUIPMENT DO I NEED?

Fancy, flashy equipment is not necessary. Buy equipment that is well made of the best materials and fitted to you and your horse. This good equipment, and the way you take care of it, brands you as a horseman or horsewoman -- not the flash and glitter of your tack.

The more formal name for your equipment is tack. The types of tack and the names of the different parts are illustrated in Figs. 16, 17, and 18. To talk "horse" you will need to know these terms and how to use them properly.

In general, your riding tack should consist of a saddle, saddle pad or blanket, headstall and a good bit, halter, and lead rope. Other equipment such as slicker, chaps, lariat, etc., will depend upon the type of riding you do. Spurs are considered optional in most show classes. If you use spurs, they should be used as aids and not as punishment or force.

Tennis shoes are not safe to wear when riding or working around horses. They are not secure in the stirrup and do not offer protection if a horse steps on your toe. Boots are the safest, but any leather shoe with a heel and reinforced toe is better than tennis shoes.

Tapaderos or light cavalry-type stirrup hoods are used many times on saddles for small riders. They are considered safer in preventing small feet from sliding through a stirrup. Show rules generally prohibit use of tapaderos in western classes. They are sometimes necessary equipment to protect the feet.

Proper care of your tack is important. Keep all leather clean and oiled. Replace all worn parts. Saddle soap should be on hand and used regularly. Neatsfoot oil is commonly used on leather but has a tendency to be messy and will come off on clothes when you ride. Many stables use other oils, applied to the underside of the leather after cleaning, that do not rub off. Use just enough oil to keep leather soft and pliable.

Build a saddle rack or rope hanger to use when storing your saddle between rides (Fig. 19). Cut an old broom handle long enough to reach through both stirrups. Twist the stirrups into the position you want them for riding and hold them in position with the broom handle every time you store your saddle. The stirrups will always hang so your feet automatically slip into them. This is a must in training stirrup leathers on a new saddle so you won't be fighting the stirrups with your feet every time you ride.

Place your saddle pad or blanket over the saddle or hang it so air will circulate and dry the sweat. Keep your blanket clean and free of caked dirt and sweat.

Hang your bridles, halters, ropes, etc., on pegs when you finish using them. Never leave them laying in the dirt or hanging on a post outside.

The headstall and bit are two very important pieces of equipment that need more attention. The headstall should be of strong leather,

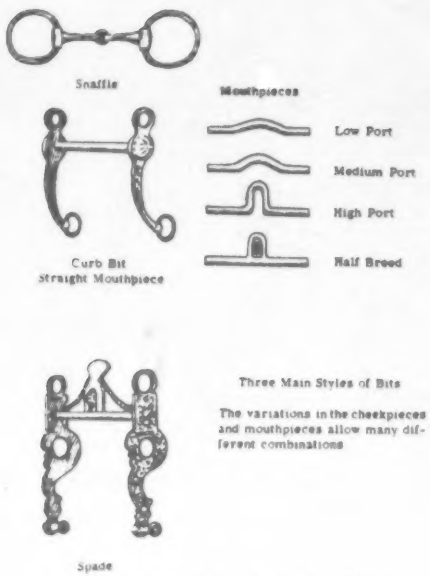


Fig. 16. Kinds and styles of bits.

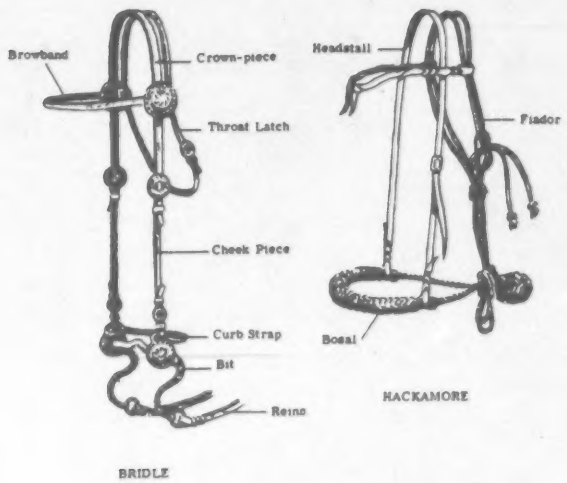


Fig. 17. Parts of a bridle and hackamore.

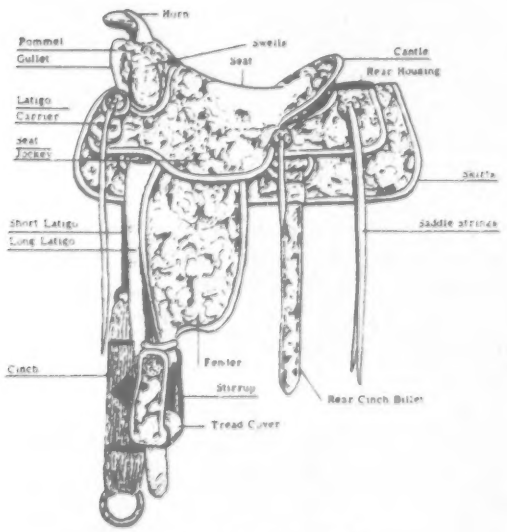


Fig. 18. Parts of a saddle.

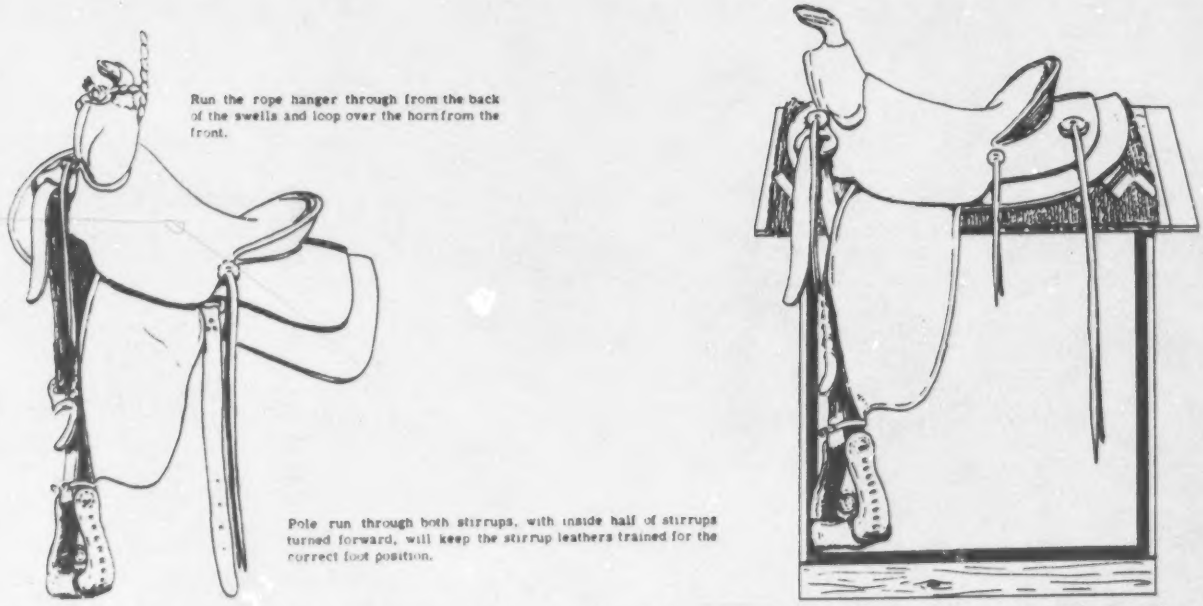

Run the rope hanger through from the back of the swells and loop over the horn from the front.
Pole run through both stirrups, with inside half of stirrups turned forward, will keep the stirrup leathers trained for the correct foot position.

Fig. 19. To hang a saddle by a rope hanger, run the rope through from the back of the swells and loop it over the horn from the front.

but narrow in width to cut down on weight. Wide leather straps and fancy metal spots are heavy for your horse to carry. The bit should be as light and as mild as is necessary to maintain control of your horse. Heavy leather and severe bits are being used too often as a substitute for good horsemanship. Do everything possible to keep your horse's mouth soft and responsive.

Use of the proper knots is important both for safety and appearance of your gear. Knot-tying and braiding is fun to learn, does not take long, and makes your equipment look neater.

Fig. 20 shows how to tie and use some of the simple knots. Remember -- your equipment reflects your pride in being a good horseman or horsewoman.

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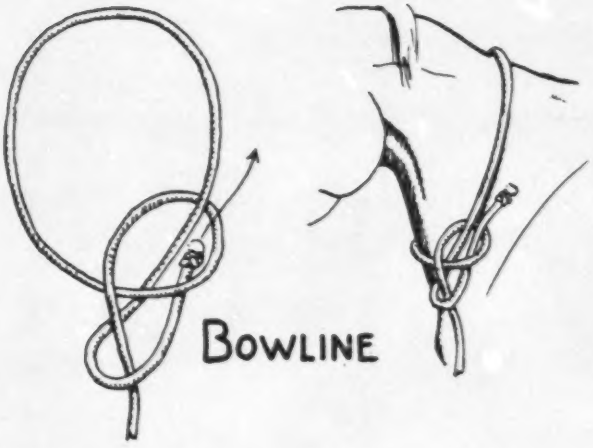
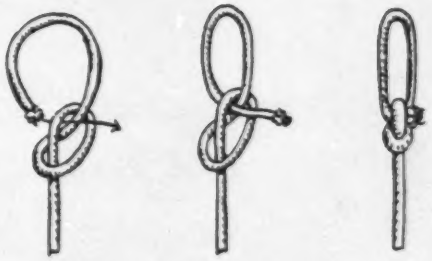
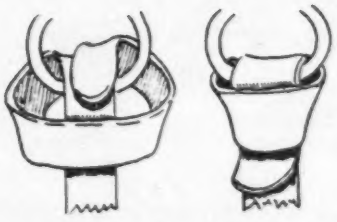


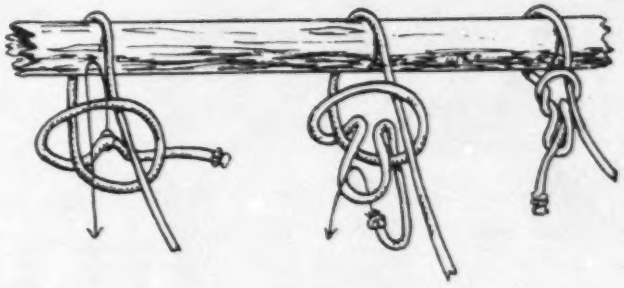
BOWLINE



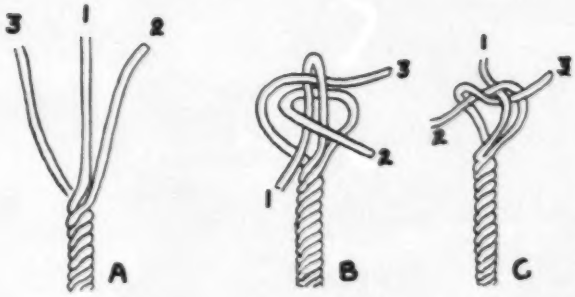
HONDA KNOT



CINCH KNOT



MANGER TIE



ENDS (1, 2, AND 3) MAY BE BRAIDED BACK INTO ROPE AT "D" OR FINISH TYING TO FULL CROWN KNOT SHOWN IN STEPS "E" AND "F".

CROWN KNOT

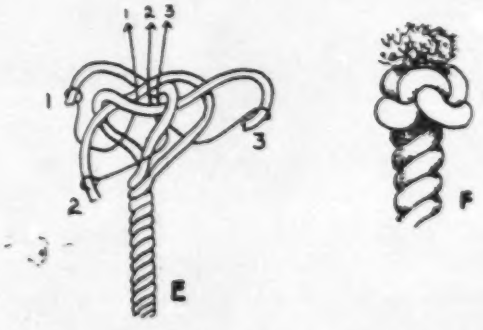


Fig. 20. Some of the common knots used around horses are illustrated here.

10. HOW SHOULD I BRIDLE AND SADDLE MY HORSE?

Develop good habits when bridling and saddling your horse. Be firm but gentle when working around the head. Your horse will respond accordingly.

Always approach the horse from the left side. Slip the lead rope or bridle reins around the neck to hold as a loose loop to hold the horse. Place the halter or bridle on the head and your horse is caught. A word of advice is in order at this point. Most horsemen/horsewomen will give their horse a small reward for being caught willingly. The reward may be a handful of grain or a good rubbing or scratching at some favored spot -- anything to show the horse it has done right. This pays dividends if the horse must be caught in a pasture.

Be safe when bridling your horse. Fasten the crownpiece of the halter around the neck or loop the bridle reins over the neck so you will have something to hold to if the horse jerks back. A good horseman/horsewoman will loop the reins over the neck anyway to keep them out of the dirt. Follow the steps shown in Fig. 21. Note how you stand -- close to the horse's neck just back of the head. This position is safe since the horse cannot throw its head and hit your face. The right arm held over the neck and poll will help keep the head down and may be dropped around the neck if necessary to help hold the horse. Work firmly but gently. With the right hand, pull the headstall up so the mouthpiece of the bit is pressing against the teeth with the left hand guiding the bit between the lips. When the teeth relax and open slightly pull up with the right hand and the bit will slide smoothly between the teeth. If the horse is stubborn about opening its mouth, press the lip against the jaw bone with your left thumb at the gap between the incisors and the molar teeth. Do not jerk or pry at the mouth with the bit.

Handle the ears gently. Move your left hand to hold the crownpiece of the headstall high above and in front of the ears. Cover the near ear and gently fold it forward with your right hand. Move the crownpiece back over the ear and your hand, then release the ear and remove your hand. Repeat with the off ear. Don't pinch the ears.

Fig. 21. Bridling a horse is usually a simple operation. Note the position of the individual and the reins looped over the horse's neck.

Check the fit of the bridle. The bit should rest in the corner where the lips join. Some horsemen/horsewomen want the bit tight enough to form a wrinkle in the skin just above the corner of the lips. The curb strap should be loose enough to allow two fingers to be inserted between the jaw and the strap. Buckle the throat latch with enough slack to prevent choking the windpipe when the horse flexes at the throat. Check to be sure all strap ends are properly fitted through the keepers.

There is a proper way to remove the bridle. Use the left hand to slide the crownpiece forward over the ears. When free of the ears, hold the headstall loosely just long enough for the horse to "spit out" the bit. You will feel this happen. Then, lower the headstall for the bit and curb the strap to fall freely from the mouth and chin. Continue holding the horse and rub the head and poll where the headstall has rested. Your horse will soon learn to expect this rubbing and will wait patiently instead of trying to break away.

Before saddling, always brush your horse and be sure the back and cinch areas are clean. Check the saddle blanket and saddle lining for sticks, burrs, or matted areas.

You are ready to saddle up. Lay the saddle blanket on the horse's back. Be sure it is even on each side. Always lay the blanket several inches forward and slide it to the rear. This smooths the hair under the blanket. Remove all wrinkles.

Fold the off stirrup, cinches, and saddle strings up over the seat of the saddle. If the stirrup leathers are short, hook the stirrup thread over the horn. Slip your right hand into the hole formed by the fork in front of the seat and lift the saddle over the horse's back. Lift just enough to clear the withers and hold the saddle steady at the top of the lift so it will settle easily on the back. You can steady the saddle at the top of the lift by placing your left hand on the edge of the front skirt. Smaller riders will find it necessary to use both hands and hold the saddle under the gullet with the left hand while grasping the rear skirts or cantle with the right hand. Many western riders have the habit of swinging the saddle up with the off stirrup and cinches flying. The stirrups are heavy and the cinch rings are hard. Watch how horses flinch their bodies to help absorb the hard knocks when the stirrup hits. Don't get this habit. Lift the saddle and settle it on the back.

Now ease the off stirrup and cinches down from the seat, holding them enough to prevent dropping. Walk to the off side and check the stirrup, cinches, and strings. Notice if your blanket is even.

Return to the near side, check the position of the saddle, raise the blanket edge where it lays over the withers to allow air space, swing the near stirrup over the seat, and cinch it up.

Several safety points should be remembered when cinching. Always reach under the belly with the left hand to get the cinch. Fasten the front cinch. Learn to tie the cinch knot. Even though you use a tongued cinch ring or a tackaberry, you should know the cinch knot in the event you need to use it.

On double-rigged saddles, remember this rule. Front cinch first, then, back cinch when saddling -- back cinch first, then front cinch when unsaddling.

Tighten your front cinch just enough to allow your hand, with fingers held flat, between the horse's body and the cinch. The rear cinch should be loose but not dangling so low your horse can catch a foot in it.

You are ready to ride, but one more step must be taken. Untrack your horse. This means to lead it a few steps. Then, check your front cinch again. You generally will be able to tighten it several notches. Check this front cinch again after you have ridden a short distance.

When unsaddling, always lift the saddle slightly before pulling it off. This loosens the grip of the sweaty leather and blanket on the horse's hide.

11. SOME BASIC HORSEMANSHIP.

There are riders and horsemen and horsewomen. Every horseman/horsewoman is a rider but not every rider is a horseman/horsewoman.

Your horse is for enjoyment. To be enjoyed, a horse should handle lightly and willingly; be safe and a pleasure to ride -- regardless of what you use it for.

You, as a rider, need to learn basic principles of riding and practice them until they become habits. These basic principles will develop your balance, ryhthm, confidence, skill, and knowledge. As you become a good horseman or horsewoman, you will learn to discipline yourself, have patience, be determined, and acquire a desire to know and apply.

Every horse is an individual. Each will respond in a different way to training, learning to do certain movements more easily and rapidly than the others. You must study how cues are used to tell your horse what you want, and how to apply these cues under different circumstances. You will always be learning -- this is necessary to become a horseman/horsewoman.

First of all, you need a true desire to be a good horseman/horsewoman. Secondly, you must be willing to be patient and take the time to school your horse before trying to perform in the events for which you are schooling. You are on the road to becoming a good horseman or horsewoman when you become as intensely interested in the progress you are making during the schooling of your horse as you are in how it will perform.

Horsemanship is the art of riding in a manner that makes it appear as if it is the easiest thing in the world to do. It can only be achieved when you and your horse are working together as a happy, relaxed team.

The following will help you in becoming a better horseman or horsewoman. It is basic material which can be applied to every type of riding with only slight modification. You will learn of different methods used by some trainers and instructors as you become more aware of what can be done with a horse.

Mounting and dismounting

These are two positions considered proper for mounting.

The first position shows the rider standing by the horse's left shoulder with the horse's body facing a quarter turn to the rear (Fig. 22).

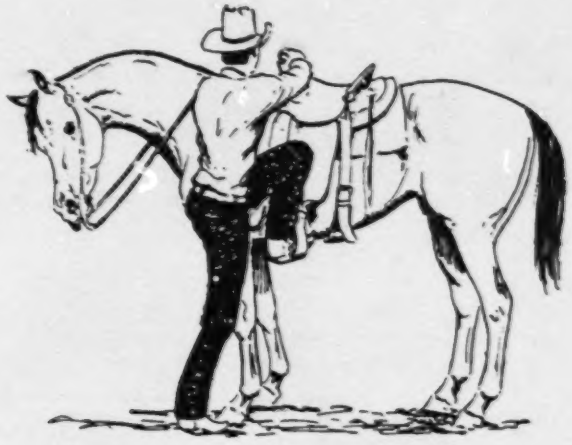


Fig. 22. The first position in mounting is the safest position to use when mounting green-broke or strange horses.

The rider's head is turned so the rider can watch both ends of the horse. This is the safest position to use when you are mounting green-broke or strange horses. It is also easier to place your left foot into the stirrup from this position. Use care to prevent the toe of your boot from raking the horse along its side as you swing up. Brace your knee against the horse for support to keep your foot out from the side.

When using this position, it is generally best to take one hop on the right leg and go into the second position briefly as you swing into the saddle.

The second position is used when you are tall enough to stand and place your left foot in the stirrup without moving back to the rear of the horse. With it, you face squarely across the seat of the saddle, and turn your left foot so the toe of your boot is pointed forward or into the cinch (Fig. 23).

In both positions, hold the reins in your left hand with just enough tension to steady your horse. Place your left hand on the neck just in front of your horse's withers, steady the stirrup with your right hand until your left foot is in the stirrup, then place your right hand on the saddle horn and your left knee against the horse.

Swing up and into the saddle with a spring, pushing with your right leg. Your body is balanced by the triangular base of support formed by your two hands and your knee. Spring hard

enough with your right leg to carry you up and over the saddle with a minimum of weight on the left stirrup. Lower yourself smoothly and lightly into the seat of the saddle.

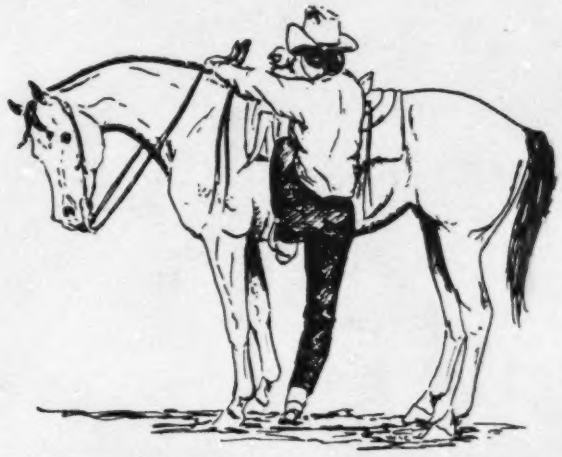


Fig. 23. The second position is the normal position for mounting for people tall enough to stand and place their left foot in the stirrup.

Learn by practice not to swing too high and plop your seat into the saddle. If you consistently pull the saddle to the side you are not swinging up hard enough.

When you dismount, use the same hand positions. Take the slack out of the reins to steady the horse, place your left hand (holding the reins) on the neck of the horse, grasp the saddle horn with your right hand, loosen your left foot in the stirrup and shift your body weight slightly to your left leg, keeping your left knee in close to the horse. Your right foot should be free of the stirrup.

Swing out of the saddle, keeping your right leg as close to the horse as possible without hitting the cantle of the saddle or the horse's rump. Do not swing your right leg in a wide arc. Keep it in close so you will be facing slightly forward when your right foot touches the ground.

Push down on your left heel to allow your foot to slip out of the stirrup. Do not roll your left foot on its side to slip it out.

Face more to the front when dismounting at the faster gaits.

The seat position

Position in the saddle is very important for correct use of aids and in maintaining balance and rhythm for ease of riding.

Sit "tall in the saddle" in a balanced, relaxed manner. Keep your back erect and flex with the horse. Do not slump in the saddle and never sit back on the cantle with your feet shoved forward. Fig. 24 shows the way not to sit in the saddle. You will find it necessary to change your seat slightly for different types of

riding but the basic principles remain the same.

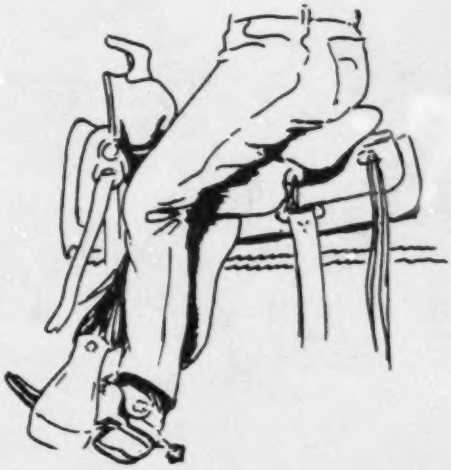


Fig. 24. This individual is sitting too far back in the saddle and bracing themseves with their feet.

You should sit where the horse can be controlled with aids, in a comfortable riding position, keeping your body weight where it will help rather than hinder your horse's movements.

In Fig. 25, note how the rider is sitting erect and securely in the saddle. The rider's seat is deep in the saddle and not up on the

Fig. 25. A rider sitting properly in the saddle and in the stirrup and holding the reins in a desired manner.

cantle. The point of contact is on the rider's crotch and not on the fleshy part of the buttocks. Light contact with the horse's body is maintained through the rider's inside thigh and the upper calf of the leg. The rider's feet are turned out slightly at a natural angle with the weight on the balls of the feet and the heels lower than the toe. You should train your stirrup leathers so the stirrups are turned at right angles to the horse's body. This prevents pressure on your feet and you can hold your stirrups more securely.

A line dropped from the center of the rider's shoulder falls near the back of the heel. A line from the point of the knee falls near the rider's toe. Your foot position is nearly correct if you can see the point of your toe as you look down over your knee. As you ride; however, your feet will move forward and back about one foot length from the above position.

Note that the rider's shoulders are back, held evenly, and the arms held close to the body. The rein hand should be held just above and in front of the saddle horn. The free hand is held in a relaxed, not sloppy, position.

Your body position will change slightly in riding the different gaits. These changes are shown under the section on gaits. You should study these changes and learn to adjust your body. Remember not to overexaggerate the degree of the change. Learn to flex your body and stay supple, poised, and balanced, in rhythm with your horse's motion.

The aids

Your voice, hands, legs, and weight are the basic aids used in controlling your horse. Be sure your horse is trained to respond to these aids. Apply the aids in a very definite manner in the early stages of training. As you progress; however, you will find your horse responding to lighter applications of the aids. If all goes well, your horse will eventually respond to very light applications of the aids until they become what is called imperceptible aids.

Specific aids for the different movements of your horse will be covered under the section gaits and movements, but the following descriptions give you an indication of how the different aids affect your horse.

Voice. Your voice is a very important aid when working your horse. Certain words such as "whoa", "easy", and "back" are readily understood by a horse. Many show horses have learned the words "walk", "trot", and "lope" or "canter" from hearing them when being lunged and when used repeatedly in the show ring. Some riders do not use complete words but have developed voice sounds like "hup" to mean something to their horses.

Be consistent, use the same word or sound each time, and repeat it often. This is the secret to your horse learning what you mean.

Your tone of voice means as much to your horse as actual words do. The tone of your voice indicates irritation, displeasure, or pleasure. Learn to always use a low, soft voice when working

around your horse. Screaming and yelling will only frighten it.

Hands. Your hands control the forehand of your horse directly by use of the reins. In advanced riding, your actions on the reins will have an indirect influence on the hindquarters.

Good hands are steady, light, soft, and firm in their actions. They can be this way only if your body is in balance and in rhythm with your horse.

As you study the sections on reining and rein cues, remember the importance of holding your arms, elbows, wrists, hands, and fingers in a relaxed, flexible manner. Hold your reins with a small amount of slack that will relieve pressure on the bit while still allowing you to keep a light contact with the horse's mouth. The degree of contact should be just enough to keep your horse working "up into the bit."

Learn to use a flexing motion as you signal or cue with your reins -- a give and take action. This can be done by a simple opening and closing of your fingers if you have the correct degree of contact with your horse's mouth. It is especially important to learn to use two hands on the reins when schooling or polishing the performance of your horse. The proper use of two hands is the mark of a horseman/horsewoman, who uses them to guide and set the horse until the horse has learned to respond to cues and to handle itself correctly. As your horse responds, you may gradually switch to the use of a single hand on the reins but, remember, at any time outside the show ring when you feel your horse isn't handling as smoothly as you desire, it is wise to use two hands until your horse is corrected.

Learn what it means to "finger" the reins and how your horse will soon respond to cues given by light "fingering." This is not cheating -- it is helping your horse learn to react to your cues in a "feather-light" manner.

If you plan to show your horse, you should study the rules on how you may hold your reins and learn to use the one which allows you to have the softest hands on your horse's mouth.

Legs. Your legs are used to (1) control the forward motion of your horse, and (2) to control the hindquarters.

When you squeeze your legs, your horse should learn that this is a signal to shift its weight back to its hindquarters, lightening its weight on the forequarters, ready to move out. Some western trainers call this, "getting its hind legs under it." Getting response to this cue is very important because you will need it every time you move your horse; when you call for a change of gait, as a preliminary cue for stopping; preparing your horse for backing; and as a corrective cue when your horse stops forward motion (gets behind the bit or rears).

Your legs control the hindquarters of your horse by pressure of your calves and heels. As you press with one leg or the other your horse might respond to that leg by swinging its hindquarters away from the pressure, or holding them from swinging against the pressure. When your horse will respond to your leg cues properly,

you will find that less cueing is required by your reins.

Spurs, whips, bats, and crops should be used only to help with your leg cueing. First, press the horse with the calves of your legs (really a squeeze); if your horse doesn't respond then use your heel. Finally, it may be necessary to tap with your bat or touch with a spur -- always in the spot where your leg will touch. Give the lightest cue first, and then if your horse doesn't respond, go the more forceful cues in order. You are then telling your horse to respond or light discipline will follow. Remember, though to give the horse time to learn what the cue means before going to punishment.

Learn to ride in balance, maintaining your position by contact in the seat of your saddle and with your thighs. Use only light contact from your knees down so your lower legs can be used for cueing.

Weight. Your body weight becomes a cue when you shift position in the saddle. This does not mean that you "throw your weight" by leaning excessively. Actually you can give a weight cue by putting more pressure on one stirrup than the other; by shifting your seat to press more firmly on one seat bone (this is the same as shifting your seat on a hard chair or bleachers); or by inclining the upper part of your body slightly to be in rhythm with your horse.

As you school your horse, you will find that response will come from very slight weight shifts. If you study the effects of your weight on the horse's back, you see that the horse is shifting its balance to match your balance. As this takes place, certain parts of the horse, especially the legs, are either held in place by weight or left free to move because they bear little weight.

Learning to be a good horseman or horsewoman is really learning the effects of the aids, how to combine them to make your horse perform, and then to use them in schooling and, finally, performing with your horse.

Body position and aids in motion

The change in position of your body, the degree of contact with your horse's mouth through the reins, and the contact pressure of your legs all change as you ride different gaits. A common fault is to overdo the degree of change. This results in a loose form of riding. You should learn to stay poised, supple, and balanced just as you want your horse to move supple and balanced.

Forward motion. Before your horse can make a move of any kind, there must be "forward motion". Backing is forward motion in reverse.

You can bend your horse's head completely around to its side and nothing will happen -- it won't move. Also, if your horse tucks its nose against its chest and stops when you are trying to make it back, you can do nothing -- until you move it ahead. In both instances you have lost forward motion.

After forward motion has begun, you will then be able to control your horse's movements.

Think of foward motion as the thrust of the horse's hind legs, with all of the power going through the horse's spine -- moving the body straight from the point of thrust. In Fig. 26, the stick can be moved forward or back and turned, but the rope cannot. Keep your horse moving straight and true from the thrust of its quarters. If you don't it will be like trying to guide the rope.

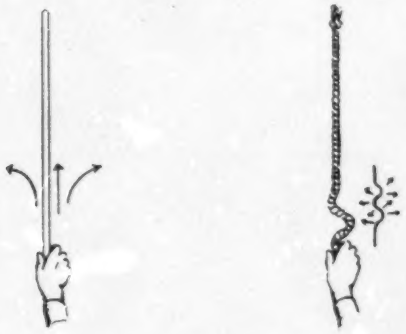


Fig. 26. Keep your horse moving straight from the point of thrust.

Walk. The walk is a four-beat gait in which your horse should stride out freely and willingly. Your body is more relaxed at the walk, but do not get into the habit of slouching your back and shoulders. Sit erect with your weight on your crotch and not on your buttocks. This position will help keep your horse walking in a brisk, alert manner.

To cue for a walk, you must settle your position in the saddle, take up lightly with the reins, and squeeze with your legs. These are the cues that alert your horse to collect itself and get prepared for some action. Think of the horse "collecting" itself as shifting its weight back and lightening the front quarters and poising its body to spring out.

When you feel the horse is collected, release the pressure on the reins and squeeze just enough to let the horse move forward. Control the speed of the motion by tension on the reins and leg pressure.

The upper part of your body is inclined forward just enough to remain in balance with the forward motion of your horse (Fig. 27).

When the horse is walking at a brisk rate, it is relaxing and bobbing its head. The rein tension should be very light to allow free movement of the head and you should be relaxed but alert in the saddle.

Slow trot (jog). The trot is a two-beat gait that should be ridden western style with your seat deep in the saddle and just enough weight on your ankles to help absorb some of the motion (Fig. 28). Posting a trot is not considered western. At a fast trot most western riders stand slightly in their stirrups. Show ring rules are not clear on what position you should use when the judge calls for an extended, or fast trot.

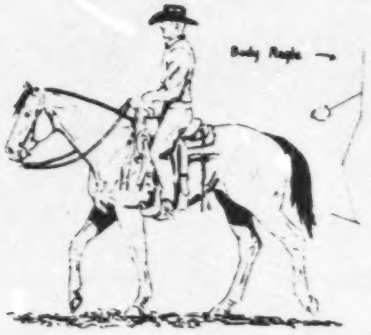


Fig. 27. Note how this individual is sitting in the saddle - deep in the saddle and inclined just slightly forward.

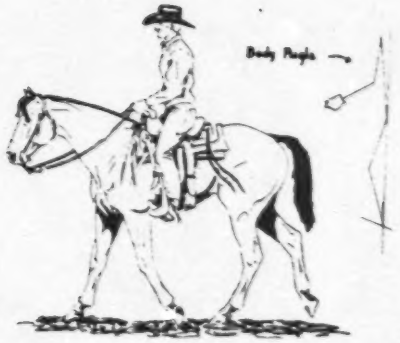


Fig. 28. For the trot, it is necessary to sit inclined slightly more forward than for the walk.

To cue for the trot, apply more leg pressure and move your horse up into the bit, maintaining just enough rein pressure to hold your horse at the desired speed. It will be necessary to shorten your rein length to allow for the natural raising of the horse's head when it trots.

The upper part of your body should be inclined to balance with the rate of forward motion. Your body balance is important so you do not get into the habit of balancing by "riding" your reins. Your arms should remain close to your body with your hands and fingers relaxed, flexing lightly with the action of your horse's mouth.

Lope. The lope is a collected, three-beat, gait ridden with your seat deep in the saddle and your body inclined forward from your hips to remain in balance with the forward motion. Relaxed hands are very important at this gait to allow rhythm with the movement of the horse's head (Fig. 29).

Cueing for a lope is done by collecting your horse, shifting your weight back to the horse's outside hindleg, and applying sufficient

pressure with your outside leg to instruct the horse to strike out in the proper lead. Train your horse to assume a lope from a standstill, walk or trot. Proper cueing is discussed under the sections on right and left leads.

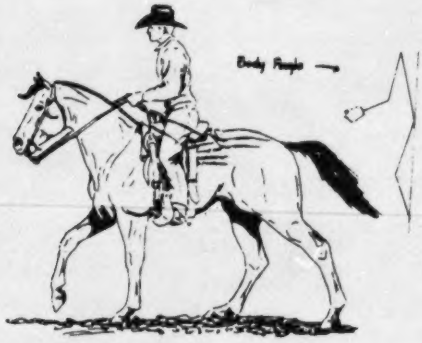


Fig. 29. For the lope, sit deep in the saddle with your body inclined forward from your hips to remain in balance with the forward motion.

Work on urging your horse from a trot into a lope in a smooth, fluid change of gait. This will make it easier for you to stay in balance and rhythm as the change occurs and you can concentrate on cueing and proper timing.

A lope is not a fast gait. The horse is working off its hindquarters, with a rhythm in its action that makes this gait a pleasure to ride if you are in balance.

Keep your body weight over your feet with slight pressure on each stirrup to help keep your balance and to allow your ankles to flex to absorb some of the weight. Your heels should be down with your toes turned out at a natural angle and your lower legs maintaining a light contact with your horse's body.

Some general pointers. Practice the proper cueing until your horse will move into any of the gaits lightly and smoothly. This will help you keep your balance and avoid any punishing of your horse's mouth and sides with the reins or spurs, which will occur if you lose balance.

Make it a habit to get light control of your horse with the reins before cueing with your legs to avoid the horse charging out and then having to be pulled back.

Try not to pull back on the reins when checking or stopping your horse. If you keep your horse working "up in the bit" lightly, you can check it or stop it by applying a resistence on the bit when you close your fingers, or hold your hands steady instead of flexing them.

Backing

Your body position for backing should be erect in the saddle with your weight slightly forward from the horse's loin to prevent interference with the hindquarters. Grip with your thighs (Fig. 30).

Fig. 30. Proper seating for backing is erect in the saddle with your weight slightly forward to prevent interference with the hindquarters.

Squeeze with your legs to collect the horse while maintaining light rein pressure to prevent the horse moving ahead. When your horse is collected, use the word, "back"; flex with your reins lightly, fingering each rein alternately; and continue squeezing with your legs. You are asking for forward motion but in reverse.

Hold your reins low to allow your horse to flex at its poll and tuck its nose. Use the light flexing pull on each rein alternately so your horse will keep its jaws and neck muscles relaxed. If the horse stiffens its jaw and neck muscles and refuses to move, loosen the rein pressure and use your legs to urge it ahead a few steps. Then, start over as soon as the horse is relaxed. Work to keep your horse relaxed and light in its head, neck, and forequarters.

Control the direction of backing by the degree of pressure of one leg or the other.

Backing is unnatural and hard on a horse. Be patient and ask for a step at a time. Stop when the horse begins to resist enough to stiffen and refuses to move. Relax it by stepping it ahead and rewarding it with a pat and soft words. Then, try again.

Increase the length of backing as the schooling progresses to the point where your horse will continue to back until you release your leg pressure and drop the reins on the neck.

Stops

A good stop is not necessarily a sliding stop. A good stop is a balanced, smoothly executed stop with the horse's hindquarters well under its body to balance its weight; and the forequarters, neck, and head kept light (Fig. 31). The horse is balanced, ready to do what is required next, whether it be to settle and stand, move on ahead, pivot, or roll back and dash off in another direction.

Timing is very important when asking for a stop, especially with a lope. You should use some preliminary cue to alert your horse that a stop is coming, which will allow it time to adjust its

balance in preparation. This preliminary cue may be a quick tap on the neck just in front of the withers, the voice command "whoa," a light flex of your reins, or a squeeze of your legs. The preliminary cue should be given a second before applying the full stop cues.

Fig. 31. For stopping, be sure to cue your horse ahead of time to alert it so it can adjust to its balance.

Cueing for a stop should involve the following action: Squeeze with your legs to get your horse to bring its hind legs under its body to balance for the stop. A firm, flexing (give and take) pull of your reins (preferably alternating the pull from one rein to the other) in timing with the horse's rhythm. Try to flex your reins in rhythm with the horse's leading foreleg hitting tne ground -- this is the moment when the horse is bringing its back legs forward.

Sit erect, "settle" your seat into the saddle with your body weight forward, and grip with your thighs. Push down on your heels to help absorb the shock. Do not get the bad habit of thrusting your feet forward, throwing your weight back, and "hauling" back on the reins.

School your horse to stop easily on the cues at a walk, then a trot, and, finally, at a slow lope. This will allow you time to perfect your cueing and timing; it will give your horse time to learn what the cues mean; and you will work more softly on your horse's mouth by going slow at first. Get the rhythm and feel, and response from your horse, before attempting to stop at a fast gait.

When stopping at slower gaits, always make your horse stop completely and stand, preferably on a slack rein. Do not let the horse walk out. It is wise to vary the time of standing so your horse will not anticipate a short stop and begin to move.

Don't rush your schooling. You are making progress when you feel the horse's hindquarters sink under you slightly when you stop. Keep working for light response and don't over do the number of times you ask for stops. As you work, be sure to vary the places where you ask your horse to stop so it will not begin to anticipate each time it passes a certain point.

Turn on the forehand

Your horse should be taught to move or hold its hindquarters in response to pressure from your heel or the calf of your leg, just behind the front cinch. This control is very important in backing, side passing, two tracking, holding the hindquarters on pivots and roll backs, and obtaining correct leads.

Turning on the forehand means that your horse will hold its forelegs in a small area and step with its hindlegs in a circle around the forelegs in response to pressure from your leg that is on the outside of the circle.

Training for this movement can be started from the ground -- in fact a horse trained properly for halter showing will respond quickly and easily to your cues.

Begin with a swing to your right. Stand by your horse's near shoulder and grasp the lead shank so you can steady the head and keep your horse from moving forward or back. Now push with your right hand at the same spot on your horse's barrel where you will cue with your heel when you are mounted. You may need to push or tap with the stirrup, a stick, or the butt of a crop, but use care. Push or tap just enough to get your horse to take one step at first -- then reward it with a pat on the neck. Don't expect a full circle right away.

Now go to the off side and work on a turn to the left. Hold the lead shank in your right hand and push on the horse's barrel with your right hand and push on the horse's barrel with your left hand. Work from both sides as you school (Fig. 32).

Fig. 32. Turning on the forehand is an unnatural movement for the horse. Be patient with the training.

When your horse is reponding to cues from the ground, try working when mounted. Use two hands on the reins at the beginning and learn the degree of tension needed on each rein to bend the horse's head while steadying the head and forehand in the position required. Do not neckrein -- this is a cue to move the forehand. Use the inside rein to bend the horse's head and the outside rein to steady the horse when you have the proper bend.

Keep your hands and reins out to the side. Bend the horse's head until you are just able to see the horse's eye. Keep your hand light, soft, and flexible.

When you feel the front of the horse is steady, and lightly bracing against the reins, begin cueing with your outside leg or heel to start your horse moving its hindquarters away from your leg. Use your outside leg -- the left leg for a swing to the right and the right leg for a swing to the left (Fig. 33). Note the position of the reins and the foot used to cue.

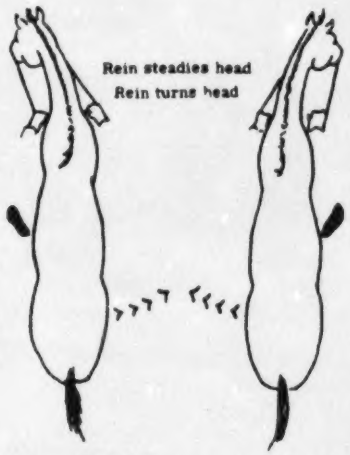


Fig. 33. Now, try turning your horse on the forehand when mounted. With proper rein tension and cuing with your heel, this can be accomplished.

Work patiently and firmly. When you get the first couple of steps, let your horse relax and reward it with a pat on the neck and a few kind words. Work a step or two at a time until your horse has learned to balance its body.

Control is important. Your horse should do a full circle or be under control enough to stop at any point of the circle you choose. Don't let it get the habit of moving around out of control.

Turn on the Hindquarters

The turn on the hindquarters is the opposite of the turn on the forequarters. Your horse will step its forequarters in a circle around its hindquarters. The back feet remain within a small area at the center of the circle. The inside back leg is the pivot leg.

The turn on the hindquarters is the basic movement for controlled, smooth, fast turns in pivots, roll backs, pole bending, barrel racing, and working cattle. The horse learns to roll back over its hocks.

Study Fig. 34 for the cues. Tuck the nose very slightly opposite the direction of the turn to take weight off the inside foreleg. At the same time bring your hands back and rein in the direction of your inside hip, which is also in line with the horse's inside

pivot hip. Shift your seat (body weight) slightly back to the horse's outside hip and press lightly with your outside leg to stop the horse from swinging its hindquarters.

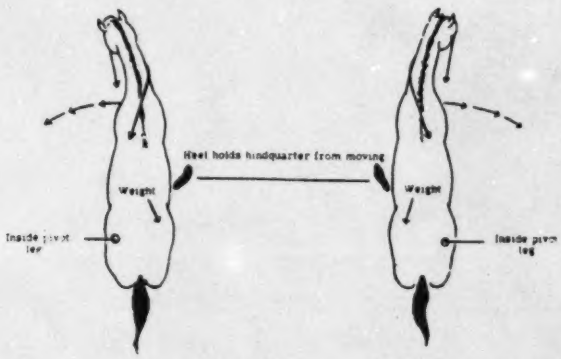


Fig. 34. Turning on the hindquarters is used in fast turns, roll backs, pole bending, barrel racing, and working cattle.

To turn to the left, tuck the horse's nose slightly to the right; rein back to your left hip as if to lightly lift the horse's front around; shift your seat to the horse's right hip; and hold your right leg against the horse's barrel. For a right turn, use the opposite cues; tuck the nose to the left, rein back to the right hip, shift your weight to the horse's left hip, and hold your left leg against the horse.

This movement requires study, patience, and practice. It is natural for a horse to spin both ends around a center point of its body like a spinning bottle. You are attempting to shift the pivot point to the hindquarters -- to the inside back leg. To keep control, just do a step at a time and not let your horse rear and spin. The crucial points occur at about each quarter of the circle. At this stage your horse must move its back legs and it is natural for it to step sideways rather than to lift its feet and put them back down. If you are not alert, the horse will move before you can stop the swing with your outside leg.

Move the front quarters a step at a time, always under control, and when you are about to complete a quarter turn, stop and hold until your horse has shifted its back legs and is again in balance before going into the next quarter turn. As your horse learns to balance over its hindquarters, you will find the forequarters moving around in a smooth, controlled circle.

When this is accomplished, you can pivot and roll back your horse without rearing, lunging, and uncontrolled turns.

Side pass

The side pass is the movement of your horse side ways, stepping to the right or left with both forequarters and hindquarters moving evenly together. The horse should have slight forward movement so the legs cross in front of the opposite supporting legs.

Side passing is necessary for smooth opening and closing of gates and is excellent for suppling your horse.

Fig. 35 shows the cues used to side pass. You will cue with the reins, your weight, and the legs.

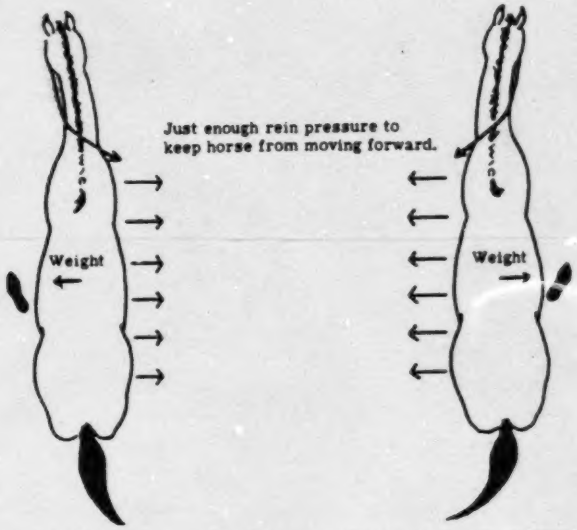


Fig. 35. Side passing requires a slight pull on the reins, a shift of your weight, and a light pressure with your leg or heel.

To side pass to the right, use the left rein to turn your horse's head slightly to the left and hold light contact with the right rein to make the horse move to the right. At the same time, shift your body weight to the left (away from the direction of the side pass) and use your left leg or heel to move the hindquarters to the right. The reverse cues are used to side pass to the left. The right rein tucks the nose to the right slightly; the left rein moves the forequarters to the left; your weight is shifted to the right, and you use your right leg or heel to move the hindquarters to the left.

Two track

Two tracking is the movement in which your horse moves forward in a diagonal direction with its front feet and back feet making two sets of parallel tracks (Fig. 36). A horse trained to two track will quickly learn to take the simple change of leads and the flying change of leads when you are ready for these movements.

Work on the two track should only be practiced for a short time and always be followed by some energetic movement straight forward. On both the side pass and the two track, the body of the horse should remain parallel to the long side of the course or arena in competition or at inspection time. The pace should remain regular, supple, and free.

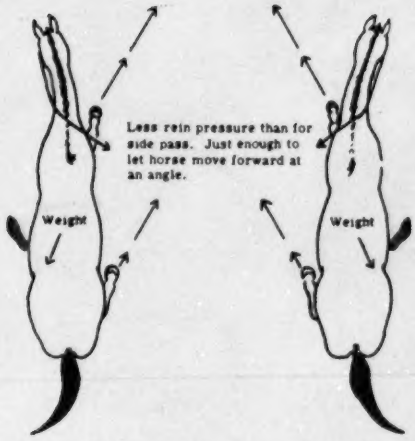


Fig. 36. In two tracking, the horse moves forward in a diagonal direction with its front feet and hind feet making two sets of parallel tracks.

Two tracking is excellent for developing muscle, coordination, and a supple, athletic body on your horse. Begin at the walk and then go to the trot and lope.

Cueing for the two track is the same as cueing for a side pass. However, your rein tension must be lighter and you will need more leg or heel pressure. You want your horse to move forward at an angle so more forward motion is needed. This is obtained by holding the reins in the same positions, but much lighter, and pushing your horse forward as well as side ways with more leg pressure.

Some horses will begin a two track more easily at a jog trot because they have more forward motion to help them move. Take advantage of this to get the "feel" of cueing and then school at the walk. When your horse will two track at the walk and trot, try at the lope.

As the rider and mount become more proficient at the early two track training illustrated in Fig. 36, more advanced two track training will become necessary (Fig. 37).

Now it is suggested that the horse is to be bent round the inside advancing leg of the rider. The horse's body is now bent away from the direction to which he is moving. The horse should not be at an angle of more than 45° to the direction in which he is moving. Good flexion at the pole is now evident as all advanced two-track movements require that the horse be bent in the direction he is looking. Further training on leads, circles, figure eights, etc., will also find the best performing horses bent toward the direction they are looking.

Leads

The correct lead. When your horse is loping, cantering, or running, its body is moving at a slight angle to the direction it is traveling (Fig. 38). This happens because one pair of legs (one foreleg and one hind leg) on the same side of the horse's body and reaching farther ahead, or "leading," the pair on the other side of its body.

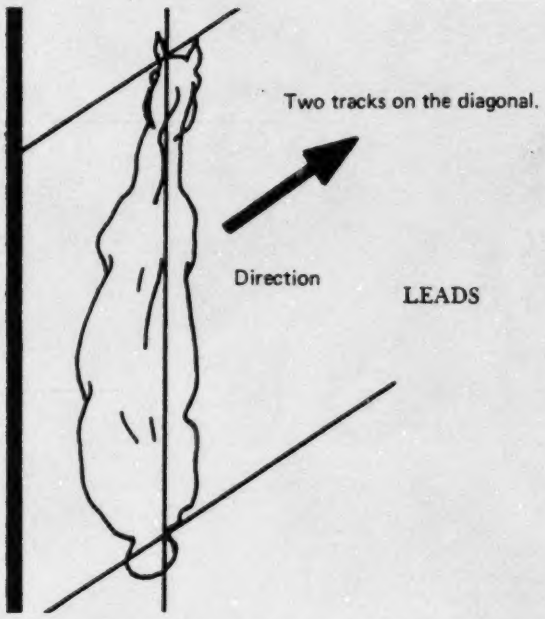


Fig. 37. In advanced two tracking, the horse's body is bent away from the direction it is moving.

If the left foreleg and left hindleg are moving ahead, the horse is in the "left lead." In a "right lead" the right foreleg and right hind leg are reaching farther ahead. If one foreleg and the opposite hind leg are leading, the horse is "cross leading." This is an uncomfortable gait.

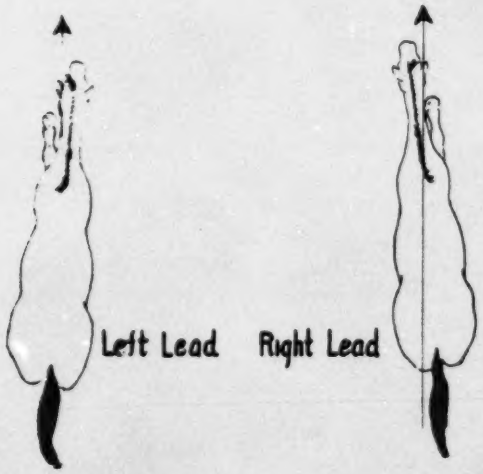


Fig. 38. In loping or cantering, legs on one side lead those of the other side (reach out farther).

The correct lead is very important when your horse is circling or making tight turns. The legs on the inside of the circle should be leading. A horse will naturally take the proper lead or change leads when running free, but will not do this when carrying a saddle and rider. Show ring rules place a great deal of judging emphasis on proper leads in performing events. A well-trained horse will change leads at the will of the rider.

Learn to know which lead your horse is in from the motion. You can check by looking down at the point of your horse's shoulders. The point of the leading shoulder is moving farther ahead of the other shoulder. Do not get the habit of leaning forward to try and see the horse's legs.

Training your horse to assume the lead you want requires patience and practice. Most horses favor one lead over the other. Work on getting either lead, but spend a little more time on the weaker lead by loping in a circle requiring that lead. Keep the lope slow and easy when schooling so you can cue properly.

Your horse should be trained to assume the correct lead at a lope directly from the walk and from the trot. At any time the correct lead is not taken, you should slow the horse to a walk or trot and try again. Patience is necessary -- don't rush.

The cues for obtaining either lead are shown and described here. Study and learn these cues, and try using them until they become habits. Several points should be remembered. Be certain to have control of your horse's head before cueing with your legs or your horse will charge out, throwing you off balance, and disrupting your cues. This will make it easier to apply your cues with proper timing. Work on cueing your horse into a lope from a swinging trot. At the trot you have more forward motion, yet the gait is slow enough to allow you to think out your cues and apply them in the proper timing.

The trot is a diagonal two-beat gait with alternate force and hind legs working together. Time your leg cues for a lope when your horse is supported on the hind leg opposite the lead desired. This will allow the horse to push off with this hind leg and bring the leading hind leg forward.

When your cues and timing are correct and your horse is working willingly, you will feel a slight lifting of your horse's body on the lead side as it takes off. This is the result of the horse shifting its weight back to the rear leg, ready to lightly spring forward and reach out with the leading hind leg. There is a smooth, gliding sensation -- and you are loping in the correct lead.

Remember these points. If you rein your horse into changing leads it will change in front but does not have to change in back -- and many don't. Use leg pressure to get the horse's hindquarters changing first. If you get the change in the hindquarters, the front quarters must change.

The following cues are used by many western riders. In early schooling they must be applied firmly, but as your horse progresses you will find it responding to lighter, more subtle applications of the cues. When used properly, you will find an improvement in riding circles, figure 8's, serpentines, quadrilles, or just turning.

The left lead. Use your reins to slightly tuck the horse's head to the right taking the weight off the left foreleg (Fig. 39). At the same time sit back and shift your seat very slightly to the horse's right hip. Apply pressure with your right heel to signal your horse to move out.

Fig. 39. For a left lead, turn the horse's head slightly to the right, shift your weight to its right hip, and apply a slight pressure with your right heel.

Fig. 40. For a right lead, turn the horse's head slightly to the left, shift your weight to its left hip, and apply a slight pressure with your left heel.

The right lead. Tuck your horse's head slightly to the left. Sit back and shift your seat very slightly to the horse's left hip. Apply pressure with your left heel (Fig. 40).

Some general tips

Learn to use two hands on the reins when schooling your horse. Keep the horse working "up in the bit" with a light feel of its mouth in your hands. This is necessary to allow you to "feel" your horse and to help it learn to position its body. As your horse learns and responds, you will get results by light fingering of the reins. The only place the use of two hands on the reins is not allowed is in the show ring. Good trainers are constantly using two hands to polish the performance of their horses.

Using two hands will also help your body balance. Your horse will work more smoothly and you will find yourself more in rhythm with its motion.

Don't try to neckrein too soon and overdo it. Learn to neckrein by laying the weight of the rein against the horse's neck -- don't pull on the neckrein. Until your horse learns to respond lightly to the neckrein, use the inside rein to tuck its nose into the turns and neckrein at the same time. Gradually you will switch to the neckrein alone.

You will need heavier applications of the cues at the beginning of schooling but you should work patiently toward response to light, imperceptible cues.

As your horse learns to respond to your leg cues, you will find it less necessary to use full rein cues. Your horse will respond to light fingering and light vibrations through the reins to the bit.

Your horse will become lighter and more responsive as you school and apply these cues correctly. It will develop "handling" abilities, and you are on the road to becoming a true horseman or horsewoman.

12. HOW SHOULD I FIT MY HORSE FOR THE SHOW?

No amount of fitting will help your horse in the show ring if you have neglected to train and feed properly. Follow a good worming program and feed for maximum body growth and a bloomy, but not overly fat, body condition.

The section on grooming and training is primarily fitting and training for a show. A handy tip for a wiping rag is to use a common household dusting cloth. These contain just enough oil to leave a gloss on the hair.

Trim the long body hairs on the belly, the fetlocks, the line of the lower jaw (but not the feeler hairs on the chin and muzzle), and on the ears (but not inside the ears). Be sure your horse is clean around the tail, between the legs, around the eyes and nostrils, and that all hoofs are clean and properly trimmed.

Excercise is important, so follow the suggestions given under training and exercise your horse 15 to 20 minutes daily. The lunge line works wonders for this.

Your horse should be trained to stand quietly and squarely, move forward and back, set up fast, and lead out smartly at a walk and a trot. Do not kick the horse's legs to move them. Learn to move the legs so they stand squarely by using the lead rope and your hand.

The horse is ready, but are you? Be fair to your horse. Dress up. Wear a clean, pressed shirt. Have clean, pressed pants, a coat or neat jacket if it is not too hot, and a tie that looks good. Your hat should be clean and in good shape, and your boots clean and shined.

Always act in a courteous manner. Don't train or discipline your horse in the ring. Be a good sport.

13. SHOWING AT THE HALTER.

Halter showing is an art and you, as an exhibitor, are in the arena to show your horse to the best advantage.

Remember that the judge wants to see your horse -- its conformation, soundness, and natural action. Have pride in your horse and your ability to show it. Learn to show your horse in a manner that will bring out its natural grace and beauty as it stands or moves (Fig. 41).

Study the following points given on halter showing. They are included to remind you of what to do. Many will appear very simple, but show judges find they are not always practiced in many shows. Use them and you will become a better showperson.

General points

Have your horse in condition and properly trained before show day. The coat should be clean, the mane and tail trimmed as required by breed standards, and the hoofs trimmed and clean (Fig. 42).

Fig. 41. Learn to show your horse in a manner that will bring out its natural grace and beauty as it stands or moves.

Fig. 42. Be sure to have your horse groomed, mane and tail trimmed, and hoofs trimmed and cleaned before show time.

Use neat well-fitted equipment. Most halter horses will be shown with a halter. However, if you should exhibit in some larger shows, you should study the rules for changes. Generally the Western horse and the English-type weanlings are shown under halter. Horses to be ridden under the English saddle may show under bridle.

Do not use a chain under the jaw -- this will cause a horse to toss its head excessively. Many showmen and showwomen do not like having a chain even on the lead strap. They feel the jingling of the chain bothers the horse. This may be especially true for many young exhibitors who have acquired the habit of jingling the chain to keep cattle alert when showing. Your horse is a more nervous animal and does not need this constant working to keep it alert.

Hold the lead strap in the right hand about 8 to 12 inches from the halter. Smaller exhibitors may need to use a longer hold on the lead strap. It is important that you let the horse's head move freely. Hold the excess lead strap in your left hand in a figure-eight coil. This is a safety method to prevent any of the coils from tightening around your hand if the horse should bolt.

Train your horse to walk out at the same rate you are walking. You should walk together so your body is even with the horse's neck about halfway between the head and the shoulders. Move in a brisk, alert manner. If you have trained your horse to walk evenly beside you, it is possible to work the horse into a trot by quickening your own pace into a trot. Your horse will move faster to stay even with you. Do not get in front of your horse or try to pull it into a trot. If it is a good horse, it will hesitate to trot out for fear of stepping on you. Always work from the side.

In the show ring

Be on time when the class is called. Enter the ring at a brisk walk and watch the ring steward for instructions on where to go (Fig. 43).

Fig. 43. Make a good impression as you enter the show ring. Bring the horse into the ring at a brisk walk.

Remember, even though the ring officials may be checking entries, the judge may be sizing up the entries as they come in, so stay awake.

When instructed to line up, go around the line and enter from the rear in the position indicated. Line up evenly with the others and stand your horse. Try to get a position where your horse's front feet will be on slightly higher ground than the rear feet. Stand your horse quickly, then watch the judge.

Don't crowd the other horses (Fig. 44). Allow room between your horse and those on either side. When the class is lined up head to tail, do not crowd the horse in front -- you might get kicked.

Fig. 44. Crowding other horses is both impolite and dangerous. Always allow plenty of room on both sides.

Remember that horses are more nervous animals than dairy or beef cattle. In the horse show ring, stay alert to prevent your horse from hurting other exhibitors and other horses from hurting you.

Stand at the left, or near side, even with your horse's head. Face forward if the judge is working in front of the class. Turn and face to the rear of your horse (the lead strap may be switched to the left hand) when the judge is comparing hindquarters from the rear of the class. Step to the front of your horse, facing the horse, when necessary to let the judge inspect the near side. Never move to the right (off) side past the center of the horse. Always move quietly and steadily to avoid exciting your horse.

A horse cannot stand alert for the full time needed to judge most classes. Let your horse relax occasionally, in position, when you are certain the judge is not studying your end of the class. This does not mean letting your horse go to sleep or get out of line. Remember that people in the crowd will be watching you. Just let the horse shift weight and relax. Watch the judge to be ready to get your horse alert.

You will be asked to show your horse in action (way of going) at a walk and trot. Watch the ring steward for instructions.

When it is your turn, lead your horse to the line indicated and stop a horse length away from the person at the end of the line. Face in the direction you are to go. Hesitate just long enough to stand your horse squarely on the line ready to walk out in a balanced, true way of going.

Walk your horse in a straight line to the person standing at the other end. Move in a brisk, alert manner and allow enough slack on the lead rope for your horse's head to move freely. Keep to the side and don't block the judge's view of the horse's feet.

When you reach the end of the line, stop a horse length away from the person at this end. Wait for some signal to turn and go back. If this is where the judge is standing, they may wish to look at your horse so be ready to stand the horse squarely.

At the signal to turn and trot back, always turn to the right. This will cause your horse to pivot in a collected, safe manner. Hold your right arm straight out, gripping the lead strap close to the halter, and begin walking to the right around your horse. This will force the horse to turn its head and then its body within a circle you are walking. Hold the horse back slightly to force it to pivot on the hind legs. If the turn is made properly, you will complete the turn with your horse standing squarely in its own tracks facing in the return direction.

It may be necessary to make your horse take a step back, halfway through the turn, if it is not pivoting correctly on its hind feet. As you complete the rest of the turn, the horse will step forward and be in line.

This turn is very simple to do and should be practiced until you and your horse can complete it properly. A horse shows more style if it pivots on its hindquarters in a collected, balanced manner.

You are now facing back to the starting point. Hesitate just long enough to have your horse balanced and ready to go. Trot to the other end of the line. Remember, that you were told when to trot the horse but your horse does not understand English. It must depend upon you for the signal to begin trotting. If you have worked at home on training your horse to walk and trot even with your body, it will get the signal from you when you quicken your pace and begin to trot.

Remember to keep your body to one side so you do not block the judge's view of your horse's legs. Hold your lead arm so the horse's head and neck are in a direct line with the rest of the body and the line of travel. If the head and neck are turned, the horse will get off balance and will throw its feet to correct the balance. For this reason continue moving a straight line even though the judge may shift to one side after you start. If you change direction when moving, your horse will be off balance and will travel crooked.

Stop your horse one length from the person at this end of the line. Wait for the signal and return to the class. Move around the end of the line and enter from the rear.

Class pattern

Classes and patterns will vary under different shows and arenas. The judge may be at either end of the line so be prepared. Stay alert and use every opportunity to show your horse to the best advantage. Make all moves steadily, quietly, and with no interference to other exhibitors. Be courteous -- you agreed to abide by the show rules and decisions when you entered.

The placings have been made. Loser or winner you are still being judged by the spectators. Retire from the arena in the same alert, brisk manner with which you entered. You want the people to remember your horse as an alert, graceful animal. Just remember that your sportsmanship is showing at all times.

14. SAFETY PRECAUTIONS

To disregard simple safety rules in handling, horses can result in serious mishaps. A knowledge of safe riding is imperative in the training of riders. Here are some basic rules for safety which you should stress continuously:

1. Never approach a horse from the rear. Even in single stalls it is possible to approach from an oblique angle at the rear.
2. Always speak to a horse before approaching or touching it. Most horses are likely to jump and may kick when startled.
3. If the horse hangs back on the end of the rope, lead it a few steps forward before touching it with your hand.
4. Keep your head in the clear when bridling the horse. The horse may throw its head or strike to avoid the bridle. Avoid bridling a nervous animal in close quarters.
5. Walk beside the horse when leading, not ahead of or behind it. Always turn the horse to the right and walk around it.
6. Use a long lead strap and both hands when leading. If the horse rears up, release hand nearest to halter so you can stay on the ground.
7. The horse is stronger than you, so don't try to out pull it. The horse usually responds to a quick snap on the lead strap or rope.
8. Never wrap lead strap, halter shank, or reins around your hand, wrist, or body.
9. Bridle reins, stirrup leathers, and cinch straps should be kept in the best possible condition as your safety is dependent on these straps. Replace any strap when it begins to show signs of wear.
10. Stand with your feet well back in the clear and reach forward when saddling the mount.
11. Never mount the horse in a barn, near fences, trees or overhanding projections. Sidestepping mounts have injured riders who failed to take these precautions.
12. Adjust saddle carefully and cinch tight enough so it will not turn when mounting. Soon after starting the ride, dismount and again tighten the saddle girth. Horses often swell up when first saddled and failure to tighten girths later can result in serious accidents.
13. If your horse is frightened of an obstacle, dismount and lead your horse by it.
14. Keep your horse under control and maintain a secure seat at all times. Horses are easily frightened by unusual objects and noises. Anticipate these and steady your horse.
15. When a horse is frightened and attempts to run, turn it in a circle and tighten the circle until it stops.

16. When riding in groups, do not ride too close to the horse in front of you and be alert for overhead tree branches.

17. Hold your mount to a walk when going up or down hill.

18. Reduce speed when riding rough ground or in sand, mud, ice, or snow, where there is danger of your mount falling or slipping.

19. Avoid paved roads. Slow your mount to a walk when crossing such roads. If the horse is a spirited or nervous horse, dismount and lead it across.

20. Know your horse, its temperament and reactions. Control your temper at all times but let the horse know that you are its firm and kind master.